REPUBLIC

DOUBLE STRENGTH

STEEL

REPUBLIC DOUBLE

REPUBLIC STEEL CORPORATION · ALLOY STEEL DIVISION

STRENGTH STEEL

REDUCES DEAD WEIGHT
. . . FABRICATION COSTS
. . . AND CORROSION LOSS

REPUBLIC STEEL

MASSILLON, OHIO · GENERAL OFFICES · CLEVELAND, OHIO

HOW REPUBLIC DOUBLE STRENGTH

In the 1920's engineers in the transportation industries were confronted with the necessity of designing lighter weight, faster moving equipment. The reduction of dead weight in railroad cars, street cars, trucks and buses became the most pressing problem of the day.

It was in 1928 that numerous combinations of copper, nickel, and molybdenum steels, having high tensile strength and good welding properties, were rolled into corrugated roofing sheets and exposed to severe industrial atmosphere on a test fence at the Canton, Ohio, plant of Republic Steel Corporation. These combinations demonstrated a strikingly high resistance to corrosion. Upon the results of these tests Republic Steel Corporation in 1933 announced "Republic Double Strength Steel"—the first copper-nickel-molybdenum steel ever offered to industry.

In the development of Republic Double Strength Steel there were three factors of major importance to consider: (1) strength, (2) corrosion and (3) welding. In order to reduce weight, it was necessary to increase the strength of the material. When strength was increased, of course, a reduction in gauge was permissible; consequently, the factor of corrosion resistance became of greater importance than with common steel of heavier gauge. Finally, it was necessary to have a material which could be welded as easily and with results at least as satisfactory as those obtained with mild carbon steel. To do this it was necessary to develop a steel with practically no air hardening characteristics.

The alloy combinations of copper, nickel, molybdenum and iron used in Republic Double Strength Steel were not selected at random. First, a number of steels alloyed with copper and molybdenum were made. Tests of these experimental steels showed high yield strength and good resistance to corrosion. Further experimentation indicated that the addition of nickel to the copper-molybdenum-iron alloy was very beneficial and later research revealed the proper ranges of the alloying elements to develop the most favorable combination of strength, corrosion resistance and weldability.

It should be noted here that there are alloying agents other than those used in Republic Double Strength Steel, whose use produces higher tensile strength. Unfortunately, however, these also develop greater hardness and air hardening characteristics which make the steel measurably more difficult to work and weld satisfactorily.

Weather exposure test fence of Republic Steel Corporation. In the foreground, mounted on porcelain insulators, are samples of alloy combinations developed in Republic's metallurgical laboratories. These samples are carefully weighed periodically to detect weight loss. The large sheets in the background are being tested for corrosion resistance. →

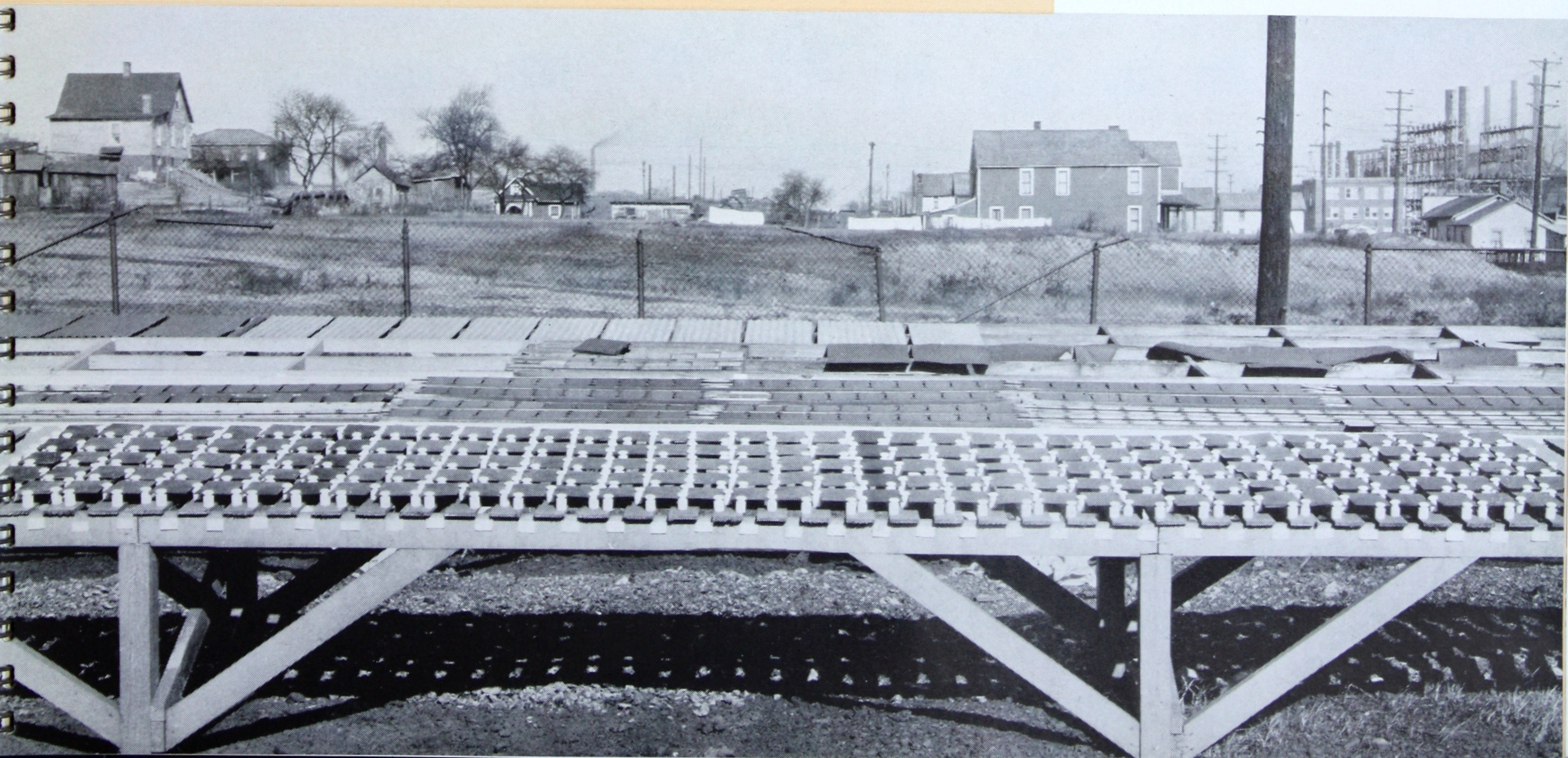
STEEL WAS DEVELOPED . . .

The effect of various alloys, when added to steel, was shown to be as follows:

Alloying Agent	Increase in Hardenability	Strengthening of Ferrite
Aluminum	Moderate	Weak
Chromium	Strong	Moderate
Cobalt	Weak	Strong
Copper	Weak	Moderate
Manganese	Strong	Strong
Molybdenum	Moderate	Strong
Nickel	Moderate	Strong
Silicon	Strong	Strong
Tungsten	Moderate	Weak
Vanadium	Mild	Weak

It is noted that copper, nickel and molybdenum, the alloying agents used in Republic Double Strength Steel, strengthen the iron or ferrite but do not materially increase hardenability. Consequently, Republic Double Strength Steel does not have the high air hardening characteristics associated with some steels of this type.

From all of this pioneering work was evolved the present analysis of Republic Double Strength, the original copper-nickel-molybdenum steel.



ANALYSIS AND PHYSICAL PROPERTIES OF

Recording the tensile strength of test specimens of various analyses on the hydraulic tensile machine.

For purposes of specification, the analysis and physical properties of Republic Double Strength, in Grades No. 1 and No. 1-A, are reproduced below:

ANALYSIS:

Composition	Grade No. 1	Grade No. 1-A
Carbon	.12% max.	.30% max.
Manganese	.50-1.00%	.50-1.00%
Phosphorous	.040% max.	.040% max.
Sulphur	.040% max.	.040% max.
Copper	.50-1.50%	.50-1.50%
Nickel	.50-1.25%	.50-1.25%
Molybdenum	.10% min.	.10% min.

PHYSICAL PROPERTIES:

	Up to ½″	
Yield Point	55,000 lbs. per sq. in. min.	70,000 lbs. per sq. in. min.
Tensile Strength	70,000 lbs. per sq. in. min.	90,000 lbs. per sq. in. min.
Elongation in 2″	24% minimum	15% minimum
Rockwell B	78-88	88-98
	½″ and over	
Yield Point	50,000 lbs. per sq. in. min.	65,000 lbs. per sq. in. min.
Tensile Strength	65,000 lbs. per sq. in. min.	85,000 lbs. per sq. in. min.
Elongation in 2″	24% minimum	15% minimum
Rockwell B	78-88	88-98

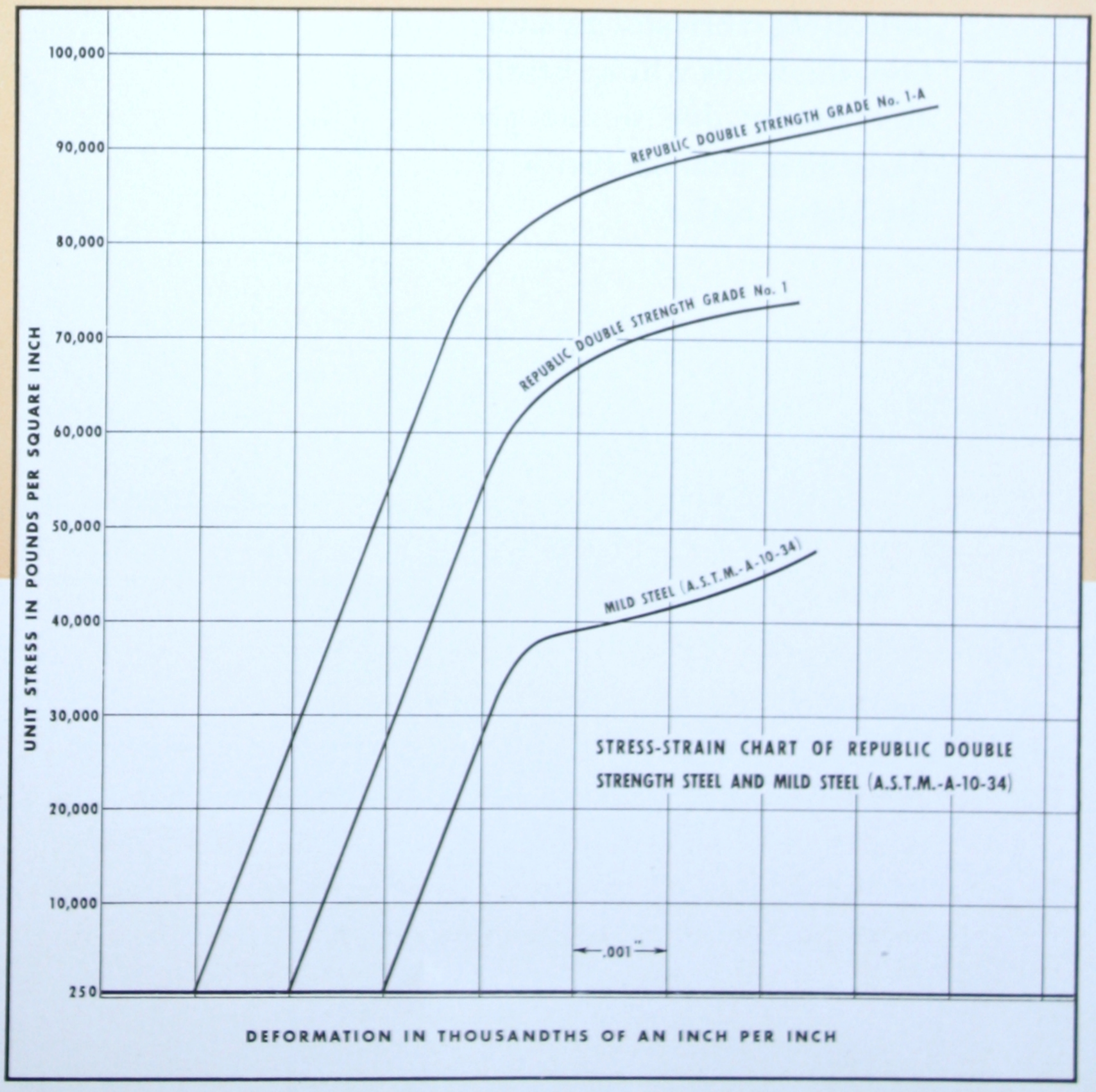
Because Republic Double Strength Steel is an iron base, low-carbon alloy, it should have the same modulus of elasticity as carbon steel. In order to show this, tensile tests were made comparing the two grades of Republic Double Strength Steel with carbon steel, A.S.T.M. Grade A-10-34. These tests were conducted on a beam type tensile machine using a recorder attachment. An initial load of 250 pounds was used to take up all the slack in the machine. These curves are shown on page 7 as they were transferred from the recorder. From these results it is seen that Republic Double Strength has the

REPUBLIC DOUBLE STRENGTH STEEL . . .

same modulus of elasticity as plain carbon steel. Consequently, in calculations involving modulus of elasticity no change need be made from that of carbon steel.

In order to further demonstrate the advantages of Republic Double Strength Steel Grade No. 1-A, two formed channels were made, one of carbon steel and the other Republic Double Strength Grade No. 1-A. Each was 7 inches high with 3-inch flanges and was 10 feet long with bearing plates on each end and in the middle, as shown in the photograph on page 8. The common steel beam was made from .325 inch thick plate and the Republic Double Strength No. 1-A beam from plate .200 inch thick. *This represents a reduction of 40% in thickness and weight.* These two members were so calculated that they should fail at approximately the same load. The yield point of the carbon steel was 32,000 pounds and that of the Republic Double Strength Grade No. 1-A, 78,500 pounds. Of course, the lighter beam would show the greater deflection.

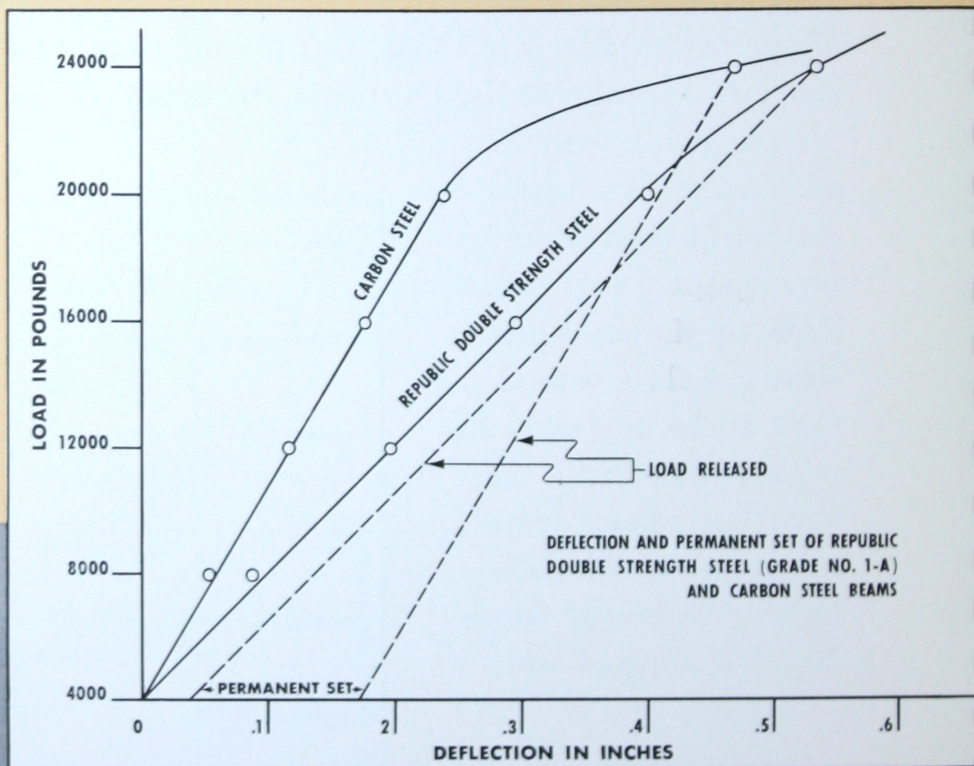
The two beams were mounted in a tensile machine as shown in the photograph and their deflections plotted. Results, shown below, indicate that at 24,000 pounds load the carbon steel beam had taken a definite set, whereas Republic Double Strength Grade No. 1-A showed only a

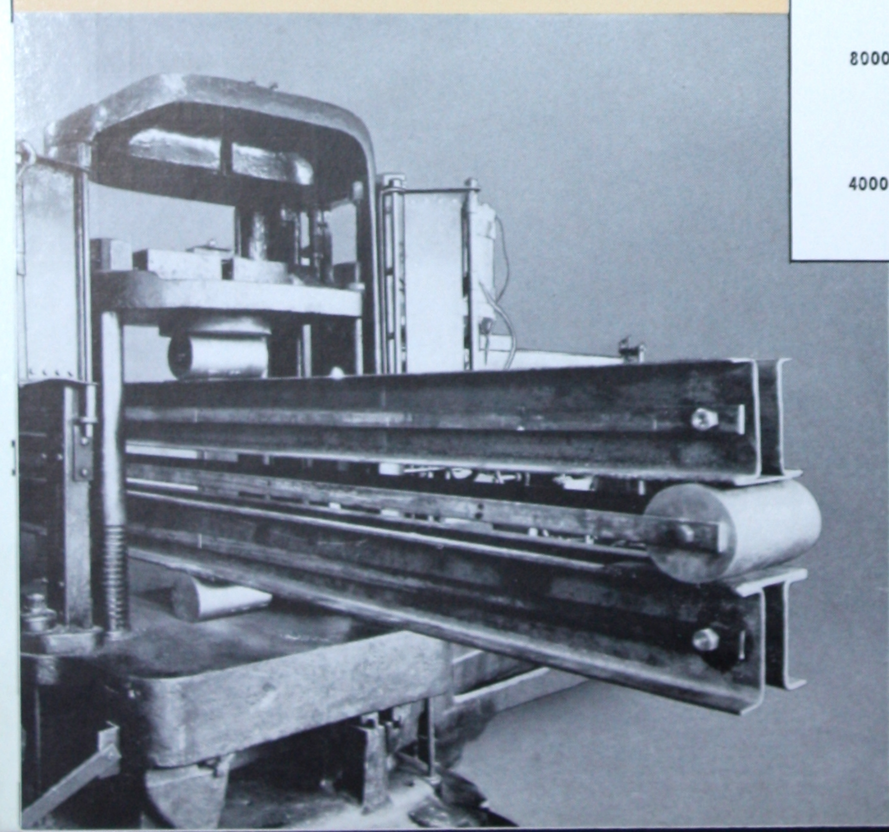


very slight permanent set. According to this test, even with a 40% lighter beam, Grade No. 1-A of Republic Double Strength Steel has a higher factor of safety than the plain carbon steel.

In design for ordinary steel structures a nominal unit stress of 16,000 pounds is generally used. In designing for light weight construction, Republic Double Strength Steel Grade No. 1 can be applied with a nominal working stress of 24,000 pounds with a higher factor of safety than common steel. Grade No. 1-A has been used with stresses up to 32,000 pounds when proper consideration has been given to stress concentration. Generally speaking, stress flow in light weight structures should be streamlined as much as possible by having smooth flowing lines and larger radii in corners than were used with conventional shapes and riveted assembly. Republic Double Strength Steel lends itself particularly well to the formed sections and welded assemblies of the newer types of railroad car design.

Carbon steels with yield points as high as that of Republic Double Strength can be produced, but in so doing, higher carbon content is necessary. These higher carbon steels will be harder than the Republic Double Strength Steel—hence, more difficult to fabricate. In addition, the welds will be brittle and harder due to the air hardening characteristics of the higher carbon.



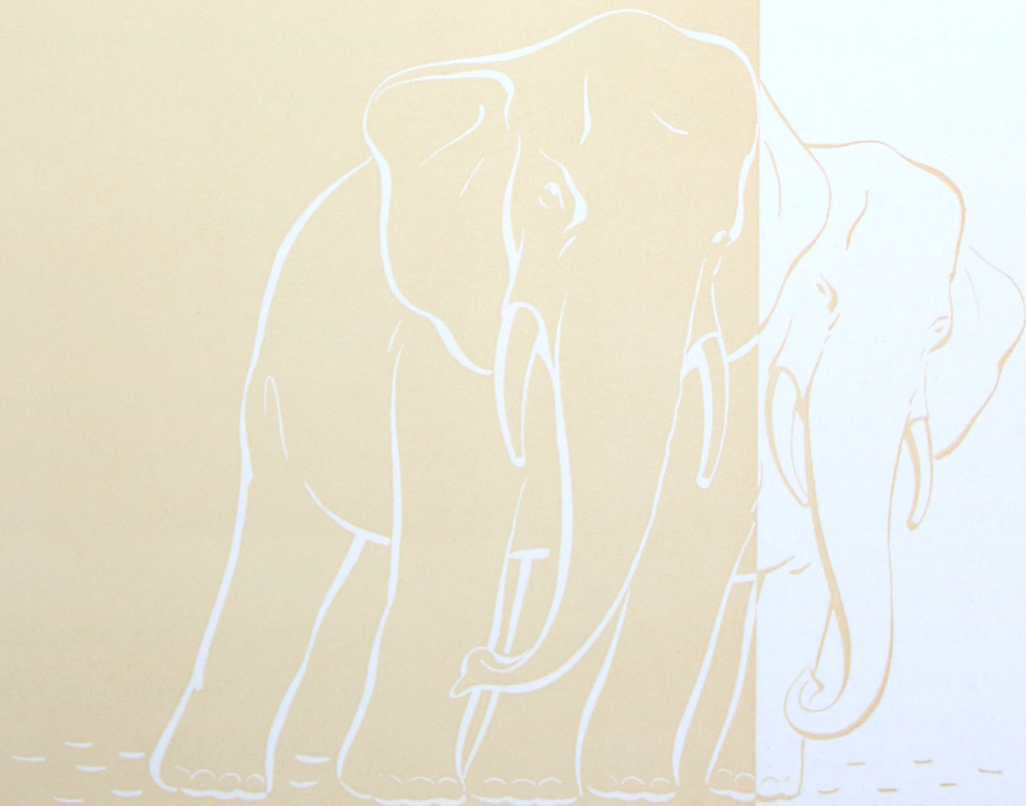


Beams in tensile machine for load deflection tests.

QUALITIES

OF REPUBLIC DOUBLE STRENGTH STEEL

Republic Double Strength Steel possesses high resistance to corrosion . . . can be welded easily . . . withstands abrasion . . . and gives extra years of service under severe conditions.



RESISTANCE TO CORROSION

It has been pointed out earlier that Republic Steel Corporation approached the development of its Double Strength Steel with several important goals in mind. One of the most important of these was resistance to corrosion.

An elaborate test was conducted over a period of seven years to determine exactly which alloys provided corrosion resistance without the serious impairment of other desirable properties.

Twenty-eight different analyses were tested with copper, nickel and molybdenum present in most. Because of the unfavorable effect of chromium's hardening characteristics upon welding, it was not used. Because it does not promote corrosion resistance and does possess air hardening qualities, manganese in high amounts was avoided. Early experimentation had revealed that not only was silicon lacking in corrosion resistance but the scale formed by atmospheric oxidation flaked readily. The cyclic repetition of scaling and flaking had the effect of markedly reducing the thickness of the material. Consequently, silicon was not considered. The product of oxidation of Republic Double Strength is tightly adherent.

COAL COMPANY COMBATS CORROSION AND ABRASION THROUGH USE OF REPUBLIC DOUBLE STRENGTH STEEL TRUCK BODIES

This 12-ton truck was the first to be equipped with a Republic Double Strength Steel body by Holland Coal Co., Chicago. The weight of the body itself was 1 ton less than that formerly used and 400 pounds less than an aluminum body of equal capacity.

After 5 years of hauling stoker coal of high sulphur content and treated with calcium chloride, a micrometer reading revealed a reduction in thickness of the material from .109 to .105 inches—only .004 inches loss despite this corrosive and abrasive service!

Holland Coal Co. reports that this truck body has been used on three different chassis *without one cent of repair expense in 5 years.* Truck bodies previously used were made from high carbon steel, .188 inches thick, and lasted only 4 or 5 years.

While these twenty-eight analyses were being tested for seven years, other combinations were studied for various physical properties. Finally, the present analysis of Republic Double Strength Steel was adjudged the best all-around combination. It not only is the *first* copper-nickel-molybdenum steel offered to industry, but, for resistance to corrosion, it contains the highest proportion of copper of all high tensile steels now available.

Although not primarily a corrosion-resisting material as compared with stainless steel, Republic Double Strength Steel does possess sufficient resistance to corrosion to permit one-third reduction in gauge or thickness (and consequently in weight) and still give equal or better life than ordinary steel. It must be remembered that corrosion resistance is not a mathematical but an empirical value and as such cannot be plotted.

It is of extreme significance that Republic Double Strength Steel consistently has offered unusually great resistance to corrosion.

RESISTANCE TO ABRASION

Republic Double Strength Steel is superior in abrasion resistance to the A.S.T.M. structural grades. Although not comparable in this respect to the so-called "abrasion-resistant steels," Republic Double Strength Steel has proved to be a highly satisfactory material for countless applications where abrasion is encountered. An excellent example of the superior abrasion resistance of Republic Double Strength Steel is the coal truck illustrated on page 10.

FATIGUE LIMITS

The majority of fatigue tests are reported in pounds per square inch made on a rotating beam type of test. However, since structural members are not uniformly stressed it is not advisable in design work to use fatigue limits established by the rotating beam test.

It has been found that 24,000 pounds per square inch fiber stress is a satisfactory figure to use in designing structures made from Republic Double Strength Steel, Grade No. 1. No failures have occurred when this allowance has been made.

WELDING QUALITIES

The term "Weldability" originally was used to specify the ability of the material to be welded, either by the electric arc, gas, or forged welding process. So much progress has been made in welding that we are now able to weld or join together many metals which, after welding, possess the properties required for the service for which they are intended. "Weldability" should mean the ability of the steel *not only to be welded together but to perform successfully the work for which it is intended after welding.*

Republic has suggested that steels be classified into five grades according to "Weldability." Class No. 1 includes steels which are commercially produced in the "as rolled" condition to minimum physical values including notch toughness. They can be welded and put into service without treatment before or after welding. These steels also can withstand the shock and vibration incidental to their service requirements through a range of temperatures encountered under the service conditions for which they are selected. *Republic Double Strength Steel, Grade No. 1, has definitely proved itself to be able to meet all of these specifications.*

In classification No. 2 are steels which should be normalized or low temperature annealed before welding to improve their shock resistance, but which otherwise possess the characteristics of class No. 1 as to retention of toughness after welding and not requiring heat treatment after welding. *In the lighter gauges, Republic Double Strength Steel, Grade No. 1-A falls into class No. 2.*

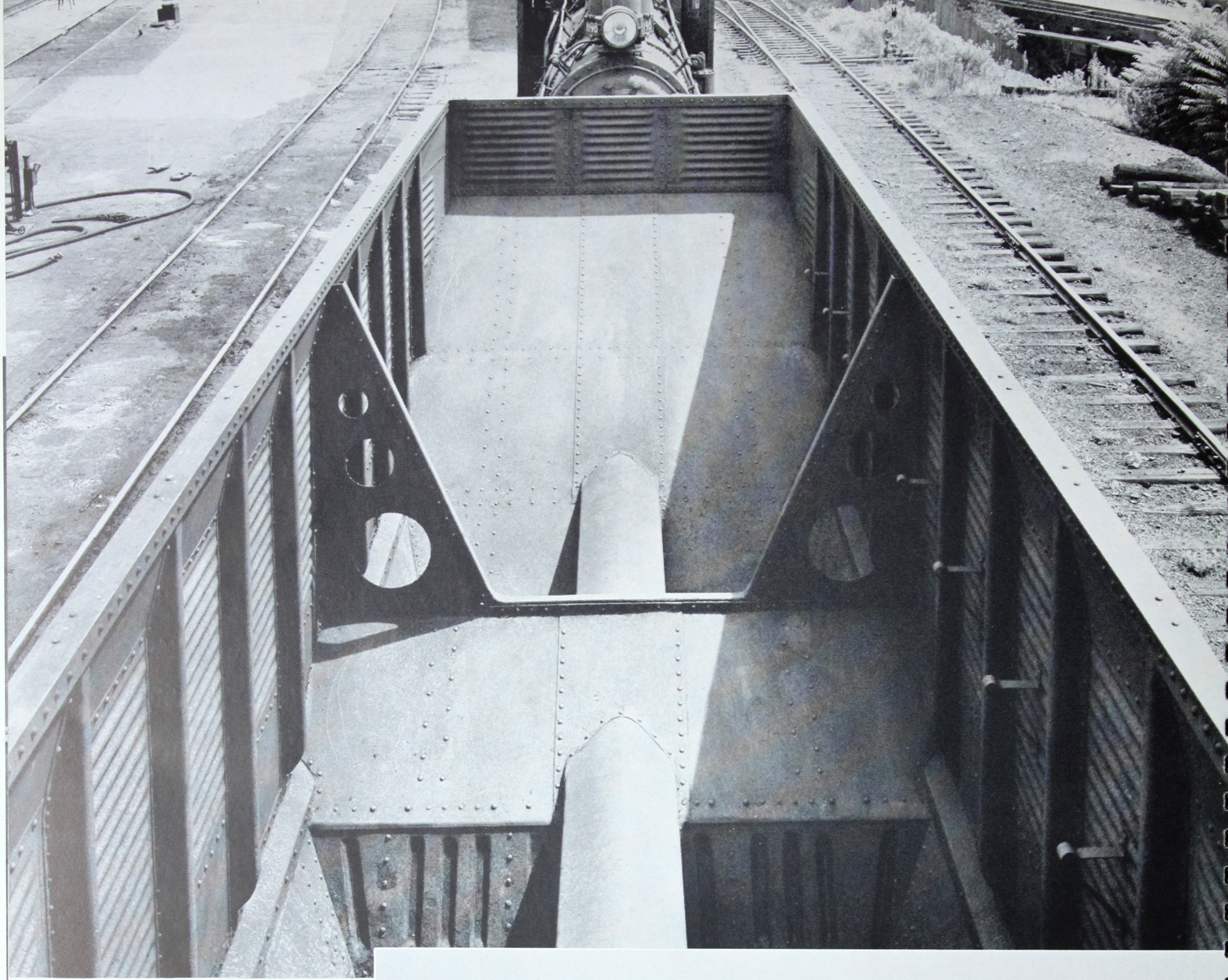
Steels in class No. 3 can be welded in the "as rolled" condition but require annealing or stress relieving after welding. *Such a steel is Republic Double Strength, Grade No. 1-A, in the heavier gauges.* Class No. 4 includes those steels which should be normalized or annealed before welding and which require stress relieving after welding. In class No. 5 are steels which require treatment before and after welding, and which should be welded at elevated temperatures to prevent cooling cracks.

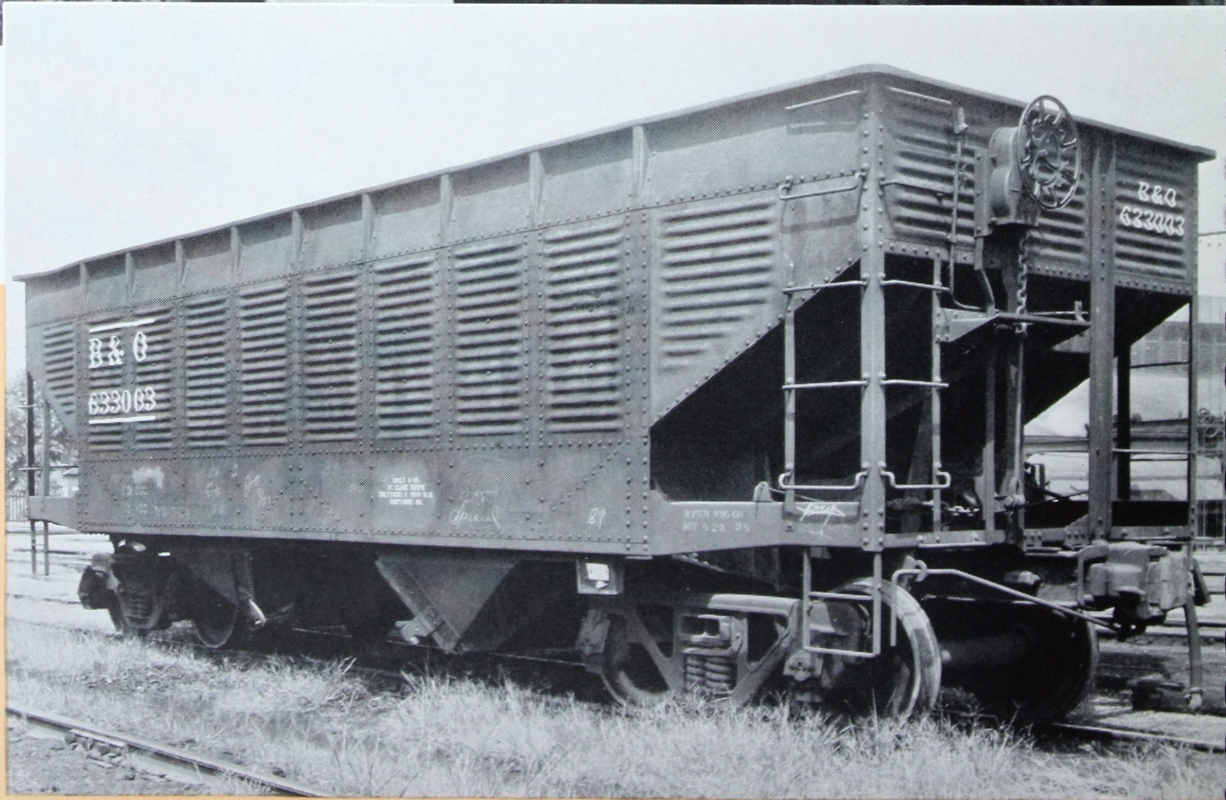
APPLICATIONS

OF REPUBLIC

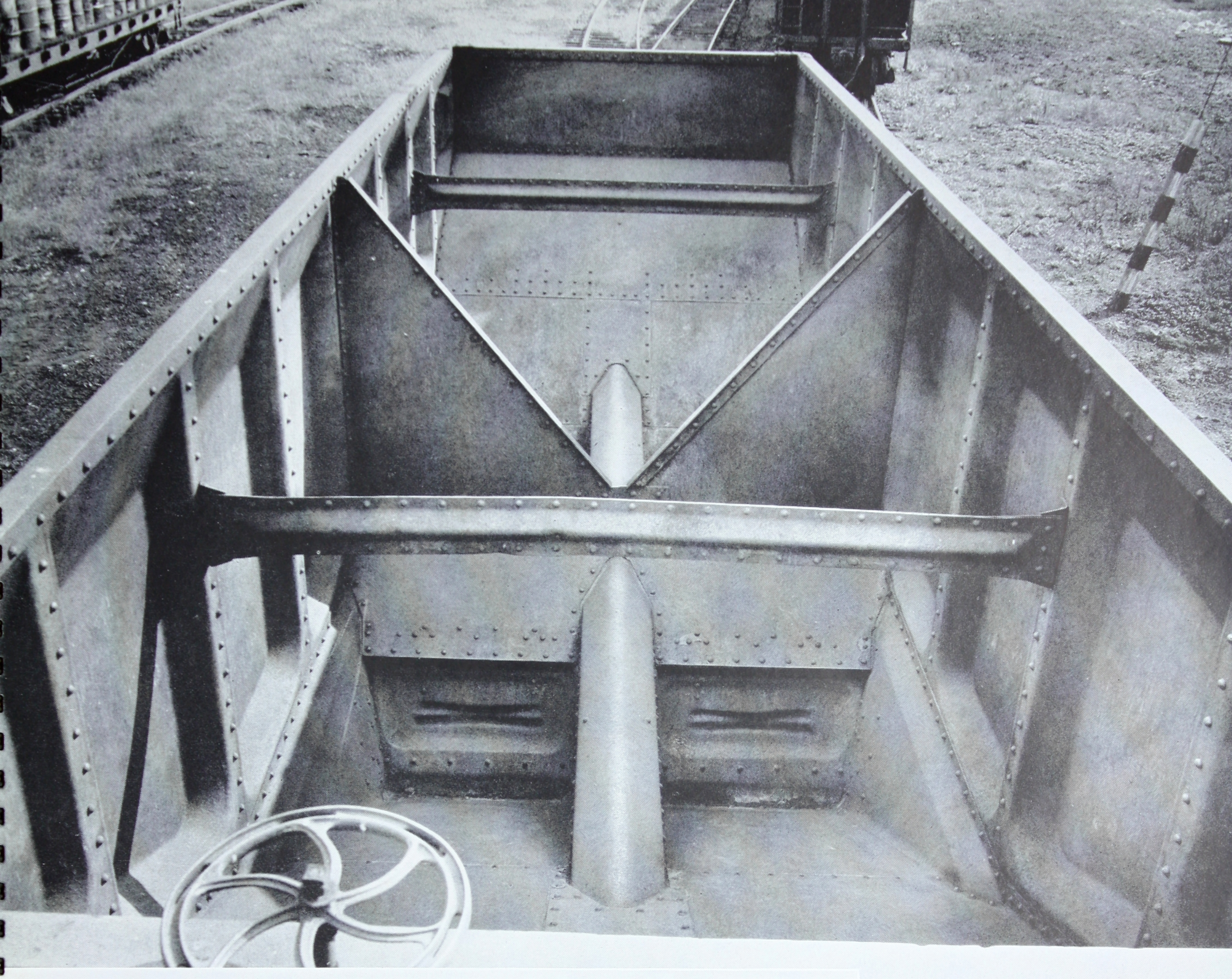
DOUBLE STRENGTH STEEL

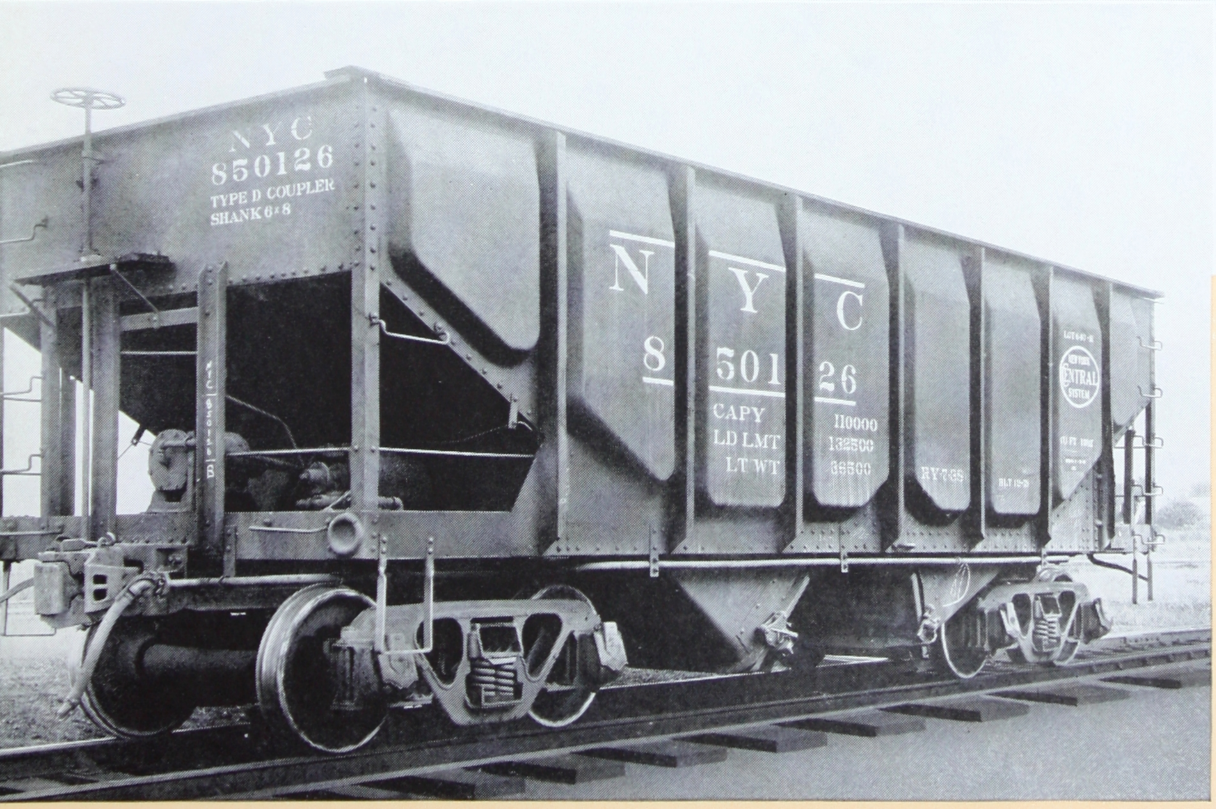
On the following seventeen pages are shown a few of the many ways in which Republic Double Strength Steel is used to reduce dead weight, cut costs and prolong equipment life. It is not possible to illustrate all of the many applications of this material. Probably there is a place in your business for Republic Double Strength Steel. To make sure, just write to Republic Steel Corporation. (See back cover.)



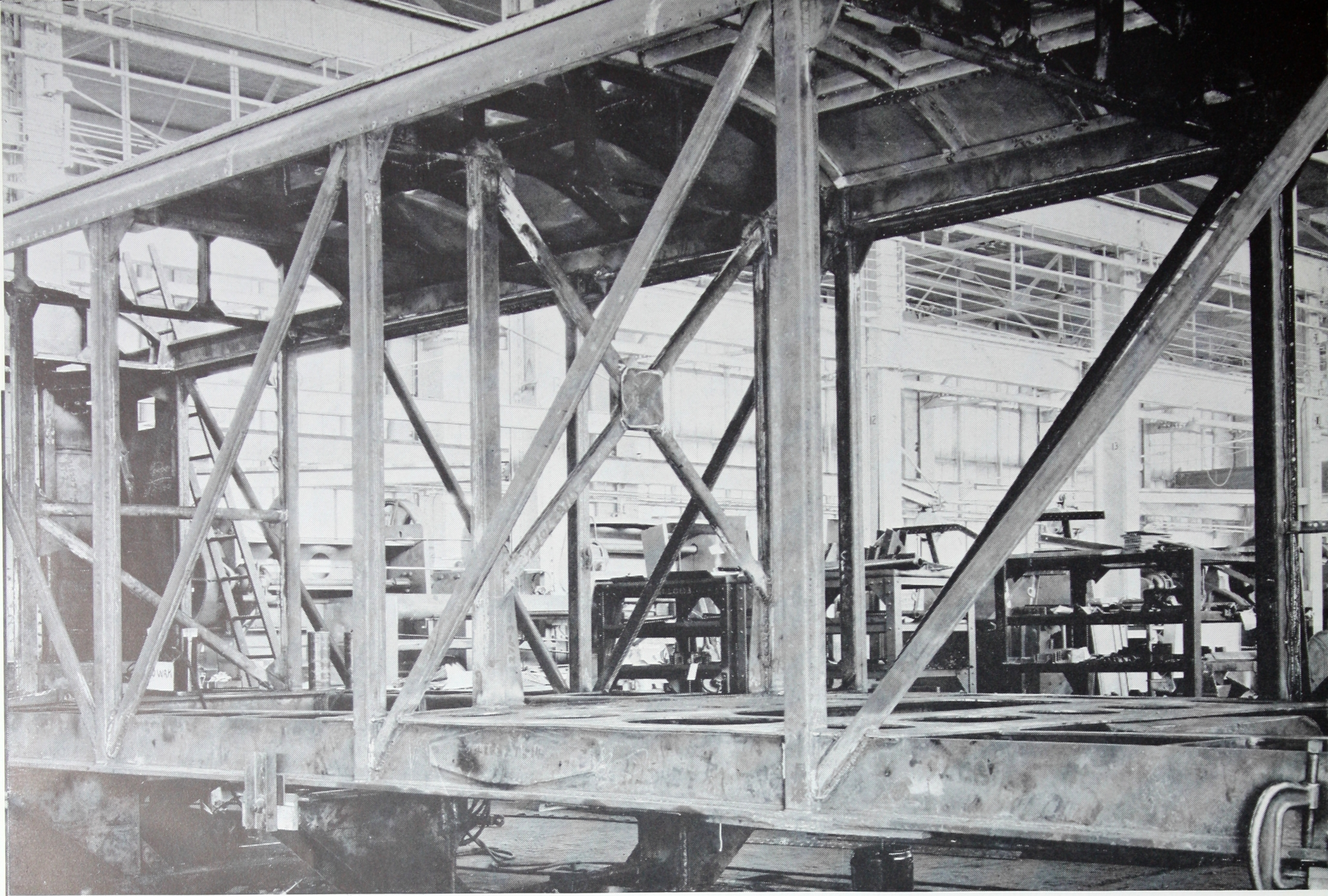


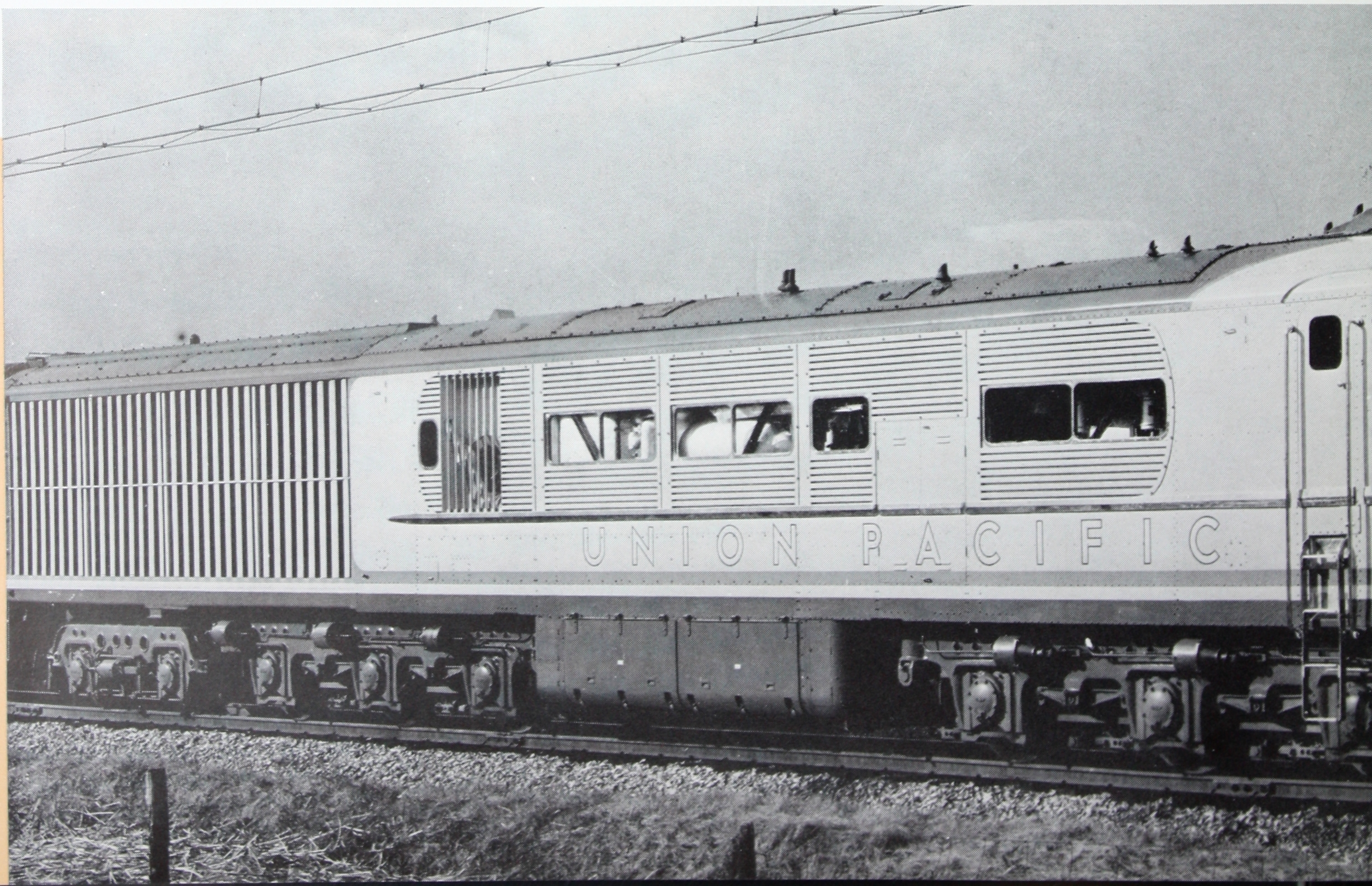
This hopper car was photographed after 4 years of tough service for Baltimore and Ohio Railroad in whose shops it was originally built. The interior and exterior appearance show that Republic Double Strength Steel has stood the gaff. The car is exceptionally light, side sheets being $\frac{3}{32}$ inch thick and the floor $\frac{1}{8}$ inch thick. Republic Double Strength Steel, Grade No. 1-A, was used.

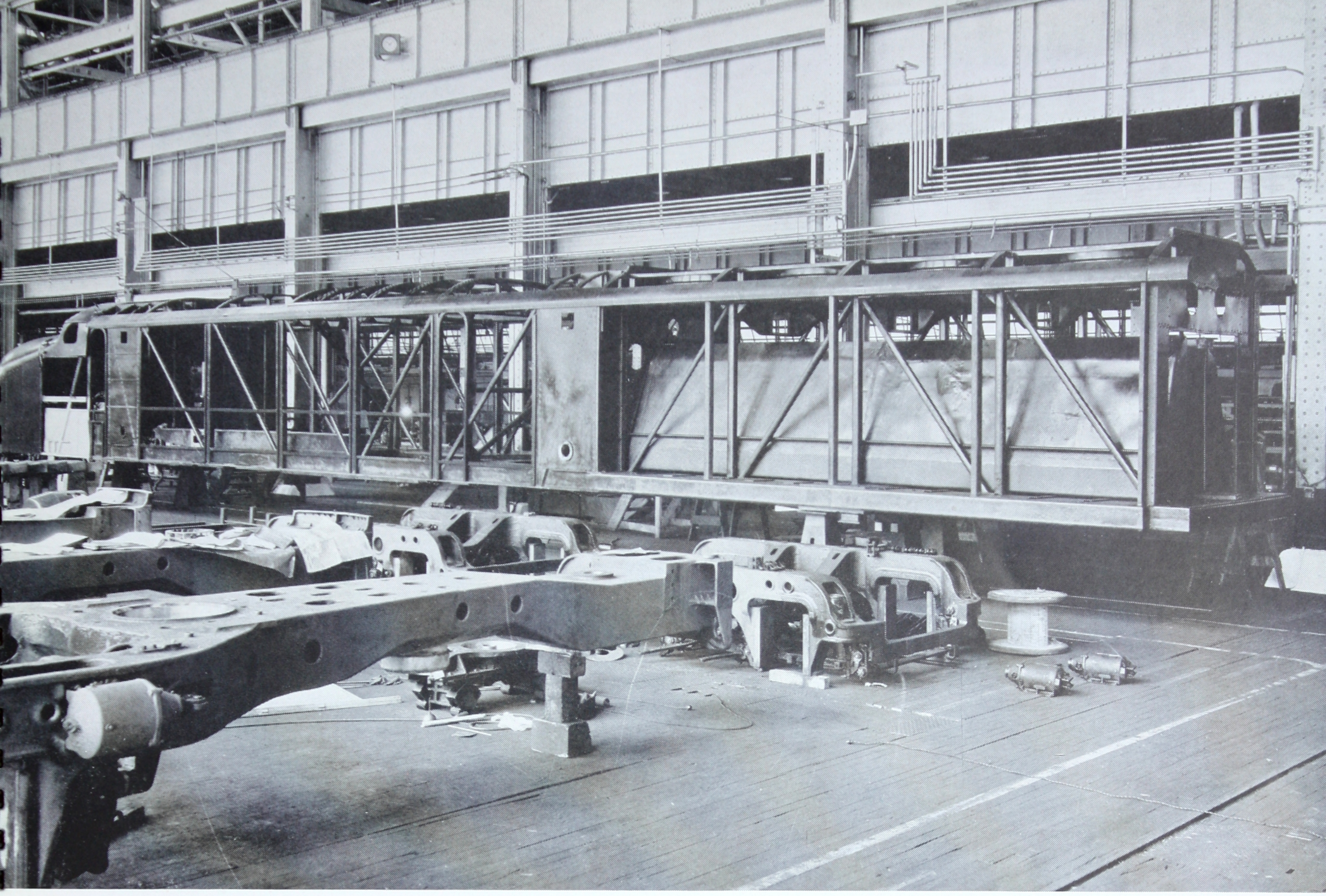




These photographs show the interior and exterior of a New York Central Railroad car after hauling coal for 3 years. The effects of wear and corrosion are negligible. Side panels, ends, and upper slope sheets were made from $\frac{1}{8}$ inch Republic Double Strength Steel. Bottom slope sheets were made from the same material in $\frac{3}{32}$ inch thickness. The panel sides were furnished by Standard Railway Equipment Corp., Chicago, and the car was built in New York Central's own shops.

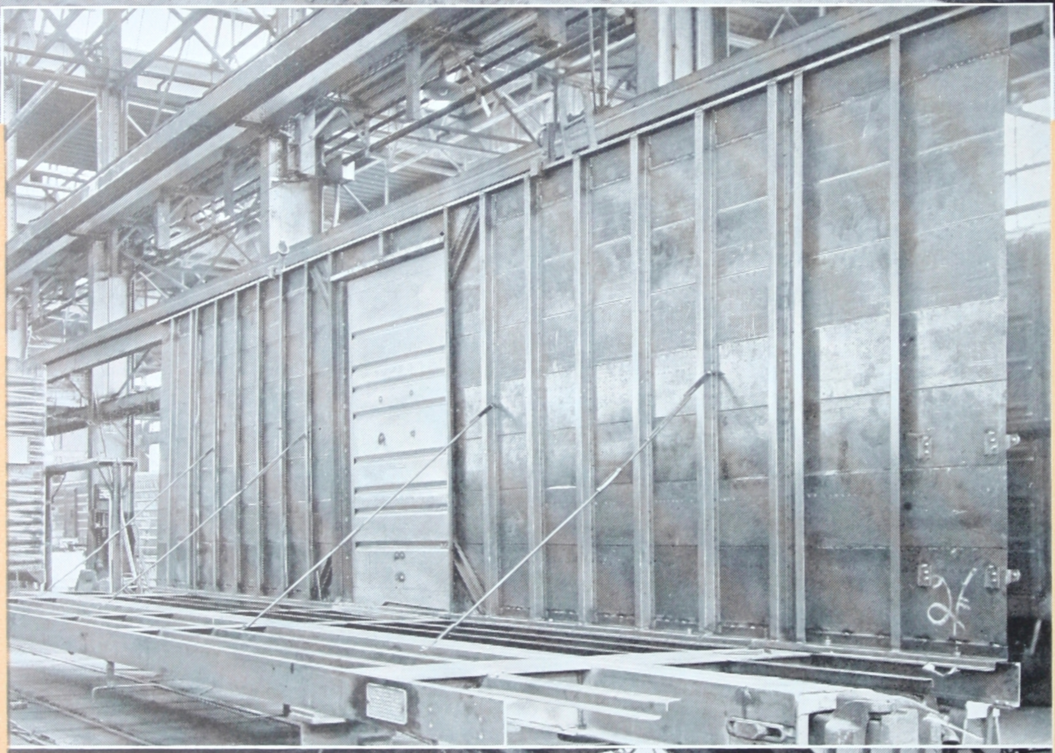


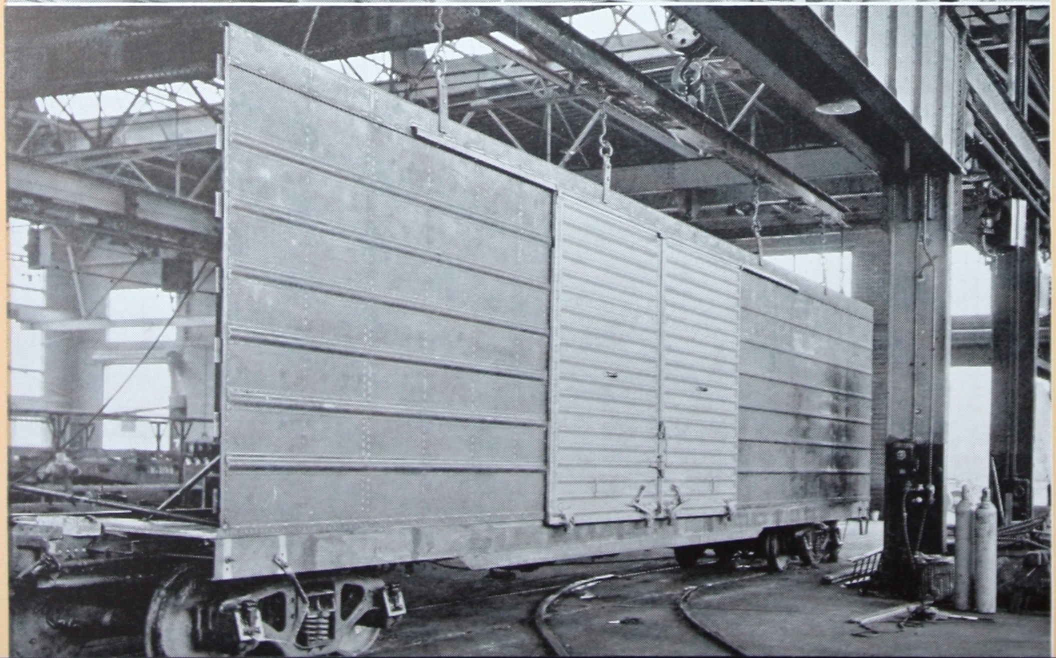

UNION PACIFIC



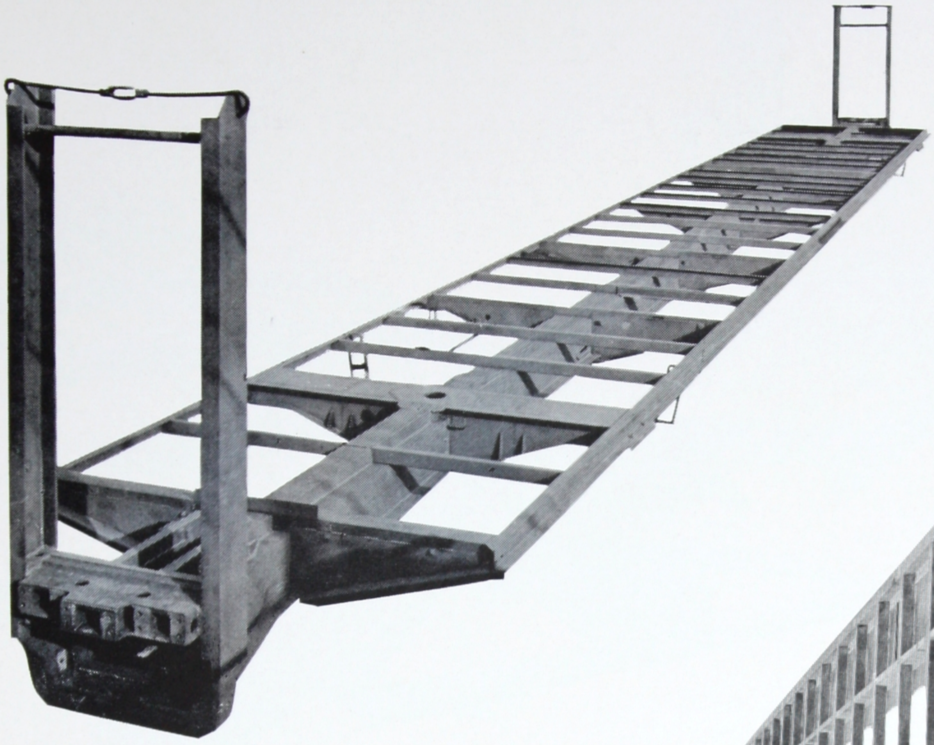
Nearly 2 years were spent by engineers in designing and building this 5,000 horsepower Union Pacific steam turbine-electric locomotive. Because of the necessity for saving weight, they used new construction methods and specified high tensile steels.

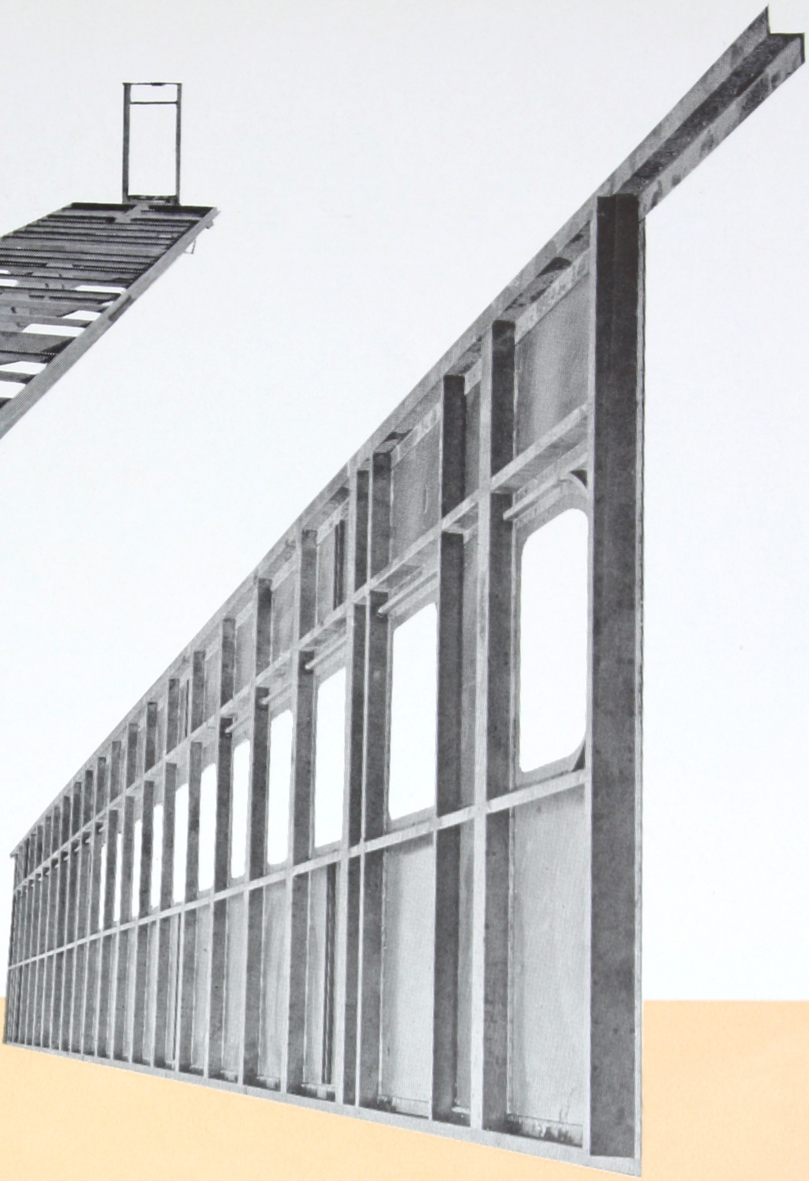
Republic Double Strength Steel was used in the entire arc-welded frame in the shape of formed sections, flat sections and rolled angles. The same material was used for all braces, the sides and roof and for the fuel and water tanks. Built by General Electric Company at Erie, Pa.



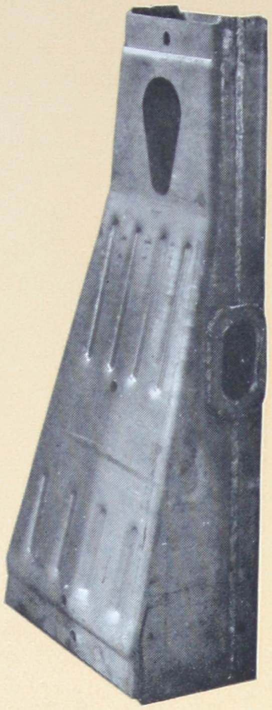


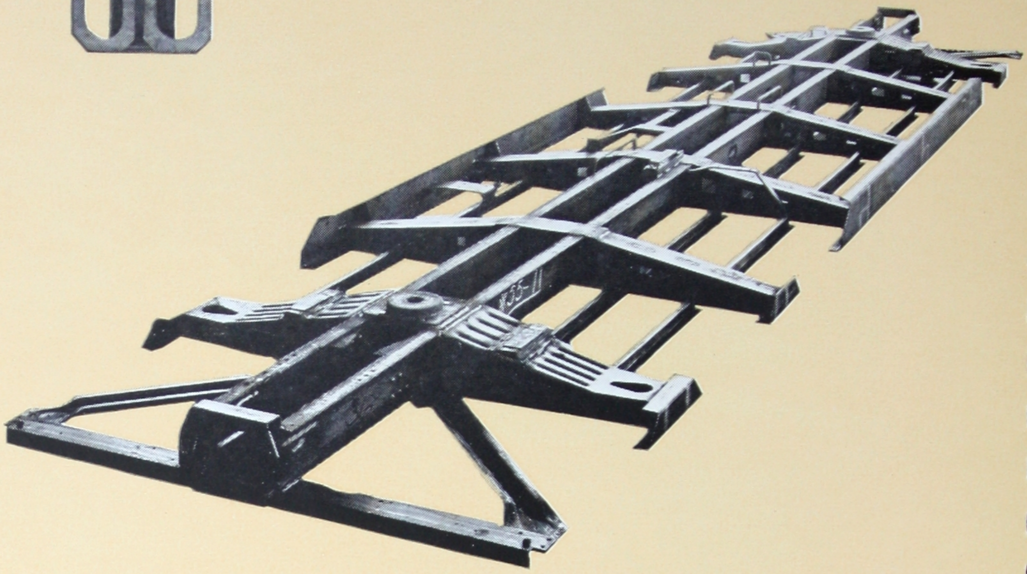
The sides of this Chicago, Milwaukee, St. Paul and Pacific R.R. car are of Republic Double Strength Steel, spot and arc welded in this railroad's own shops. The car is about 9,000 pounds lighter than it would be with A.A.R. or equivalent construction. When its present construction program is completed, this company will have placed 4,688 of these cars in service since August, 1936. A total of 16,134,000 spot welds already have been made without any trouble traceable to the material used—Republic Double Strength Steel.





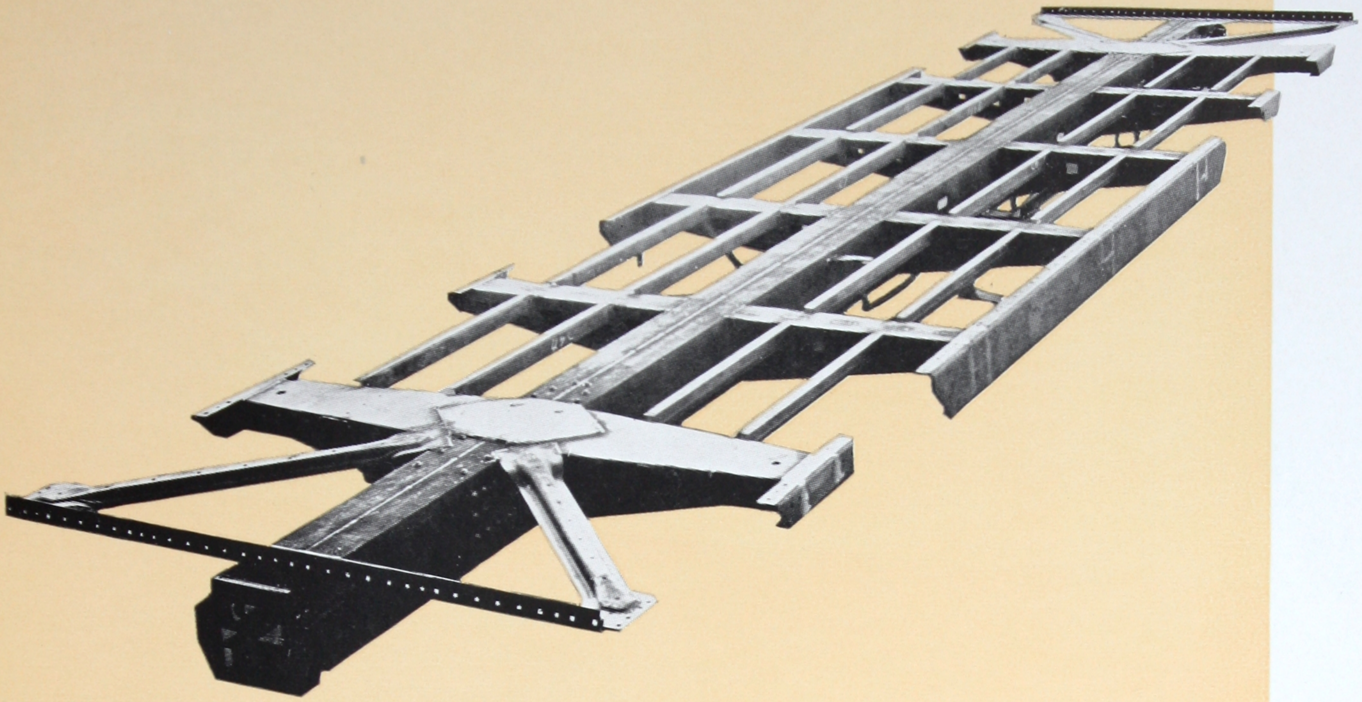
These three photographs show the construction features of the new, light-weight, stream-lined coaches being built by American Car and Foundry Co., New York, N. Y., for Delaware and Hudson R.R. Co. All framing members are of Republic Double Strength Steel. Spot and arc welded construction was employed throughout to obtain full benefit of the high physical properties of Republic Double Strength Steel. (See photograph of spot welder on page 36.)



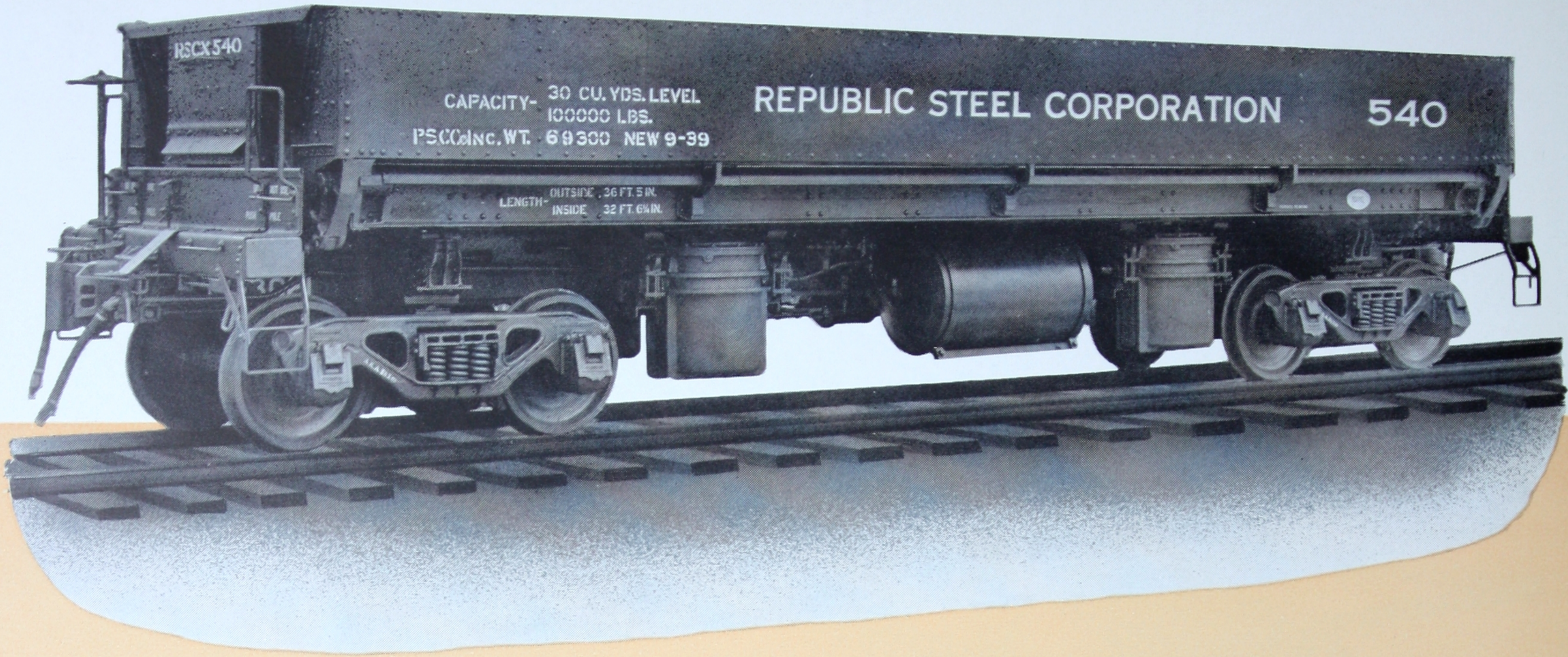


Above: A Chicago, Burlington and Quincy hopper car with complete body made from Republic Double Strength Steel sheets. It was after this material proved so satisfactory on 100 cars that it was specified for another lot of 136 cars. All cars are of riveted construction and were built in the car building shops of this railroad.

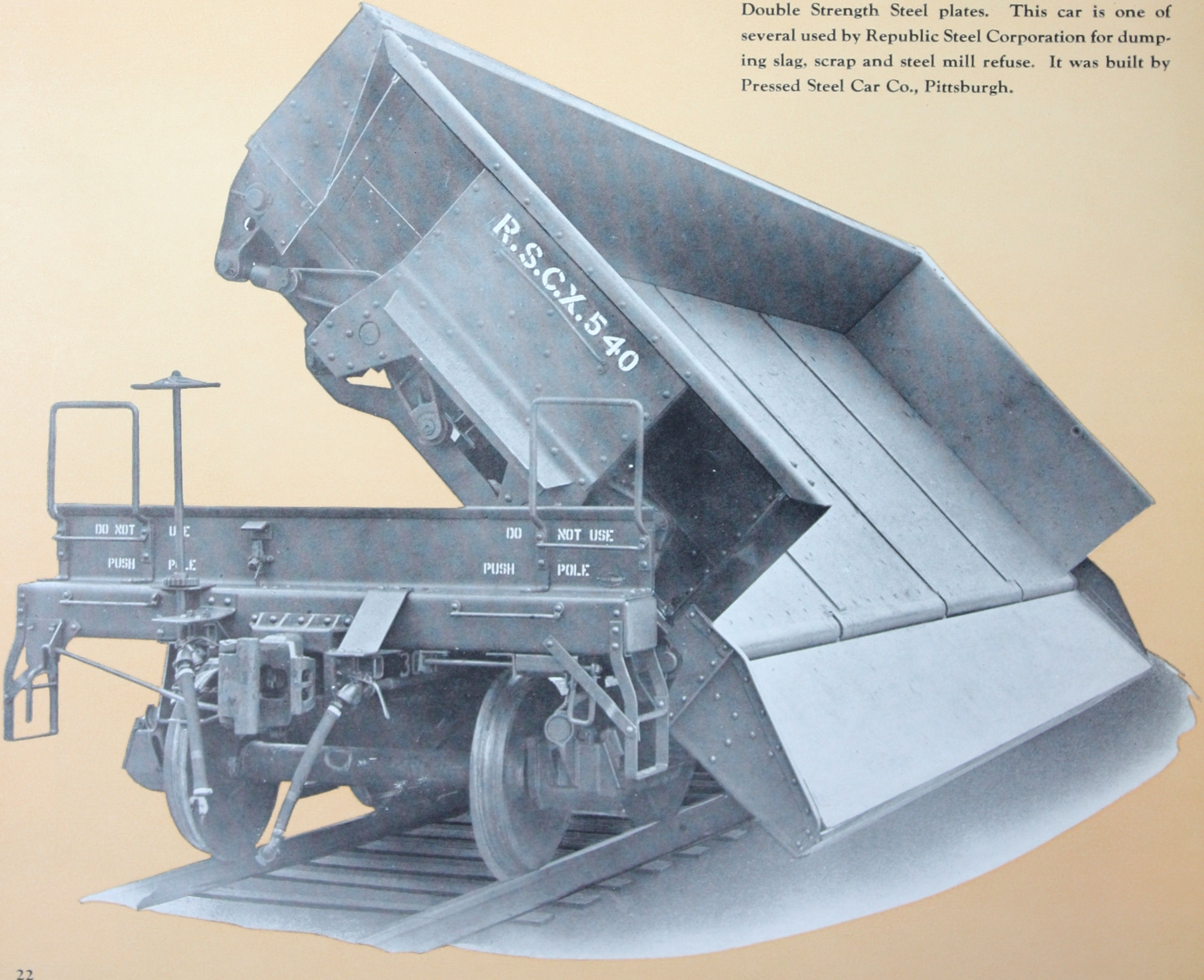
Right: The first light-weight all-welded refrigerator car which was built by Pullman Standard Car and Manufacturing Company, Chicago, in January, 1936. Roof, sides, ends and ice racks—all were made from Republic Double Strength Steel sheets. Weight was reduced about 12,000 pounds. After 107,000 miles an inspection showed the car to be in very good condition.

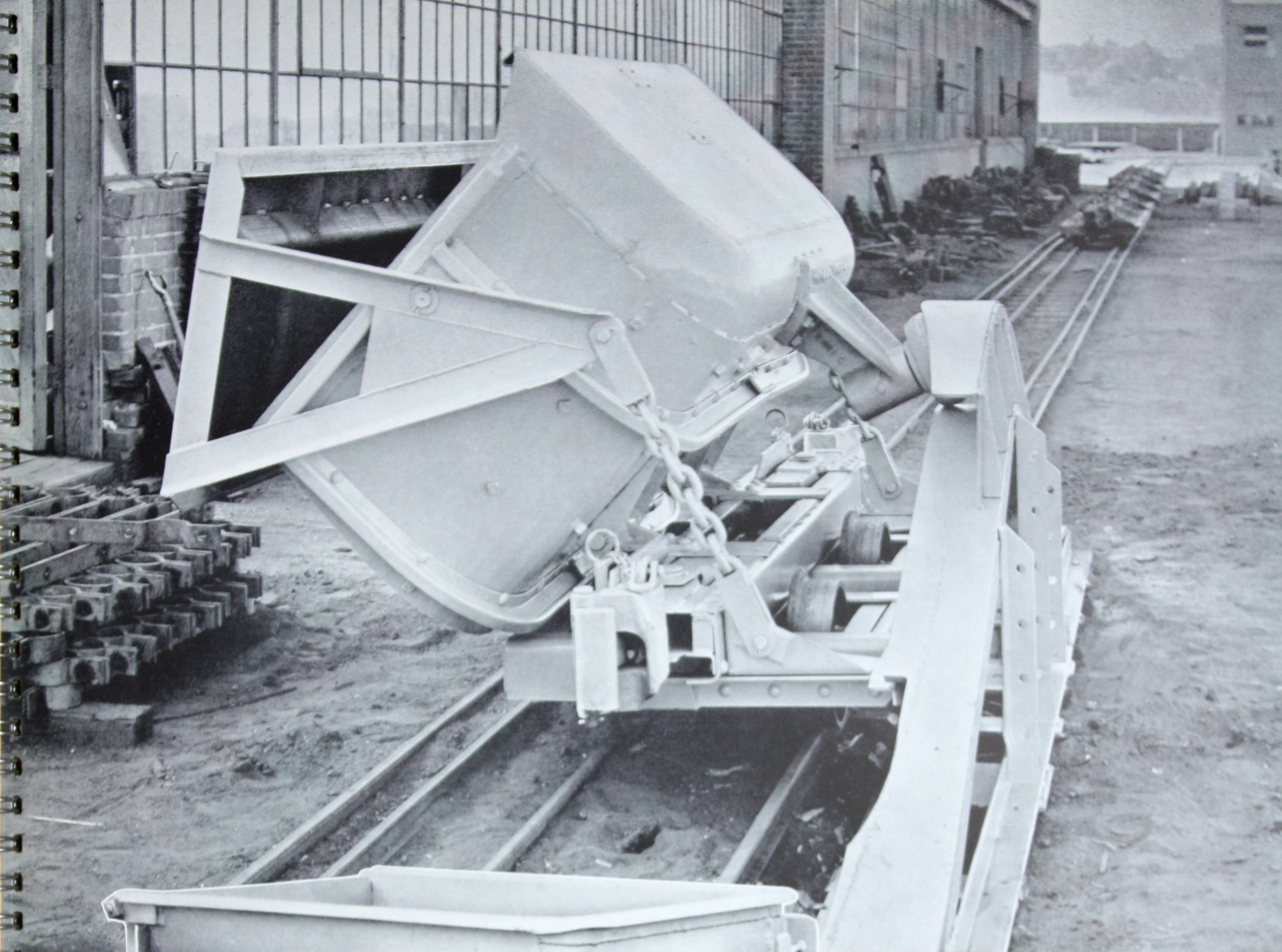


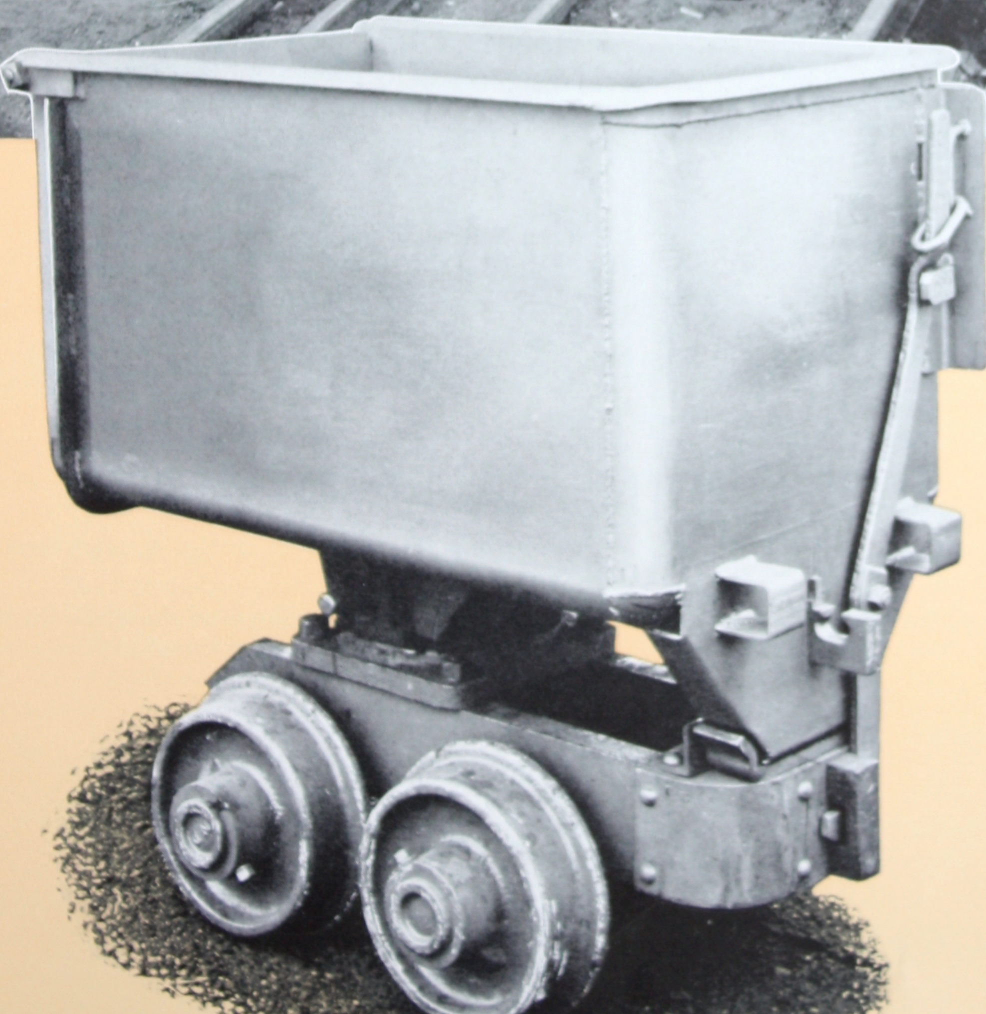
Across the top of these pages are shown bolster sections and top and bottom views of the underframe assembled complete, built for Union Pacific Railroad. The builder, Mt. Vernon Car Co., Mt. Vernon, Ill., writes: "We have had no difficulties either in forming or welding Republic Double Strength Steel. After we got into production on this class of material our forming and welding gave us no more difficulty than ordinary open hearth steel."



Dead weight was cut 12,000 pounds by making the complete body of these dump cars from Republic Double Strength Steel plates. This car is one of several used by Republic Steel Corporation for dumping slag, scrap and steel mill refuse. It was built by Pressed Steel Car Co., Pittsburgh.

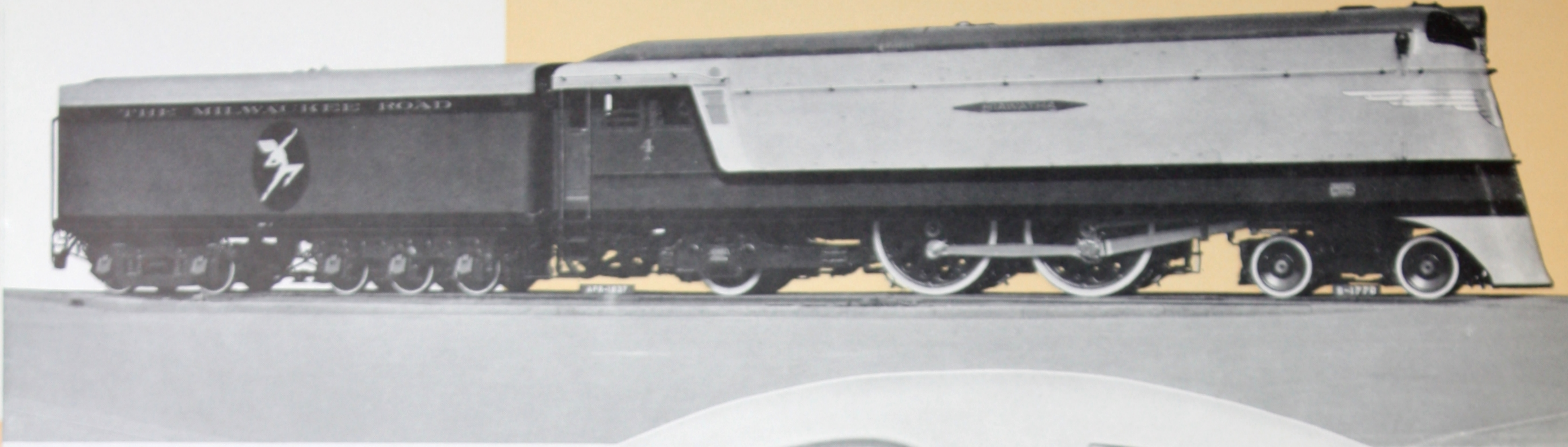






The Granby type ore car shown above in dumping position, has a capacity of 50 cubic feet and is one of many built by C. S. Card Iron Works Co., Denver, Colo., for the Anaconda Copper Co., Butte, Mont. Republic Double Strength Steel, Grade No. 1-A, because of its abrasion resistance, was used for body. Strength and shock resistance were the reasons for using Grade No. 1 for the under-frame. The car is an all-welded construction. No subsequent annealing was necessary.

Grade No. 1-A was used for the 14 cubic feet capacity hand dump car shown at the left. Both cars are made entirely from Republic Double Strength Steel with the exception of the castings.



Top: The sheathing on the locomotive of the "Hiawatha" built by American Locomotive Co., Schenectady, N. Y., was made from Republic Double Strength Steel.

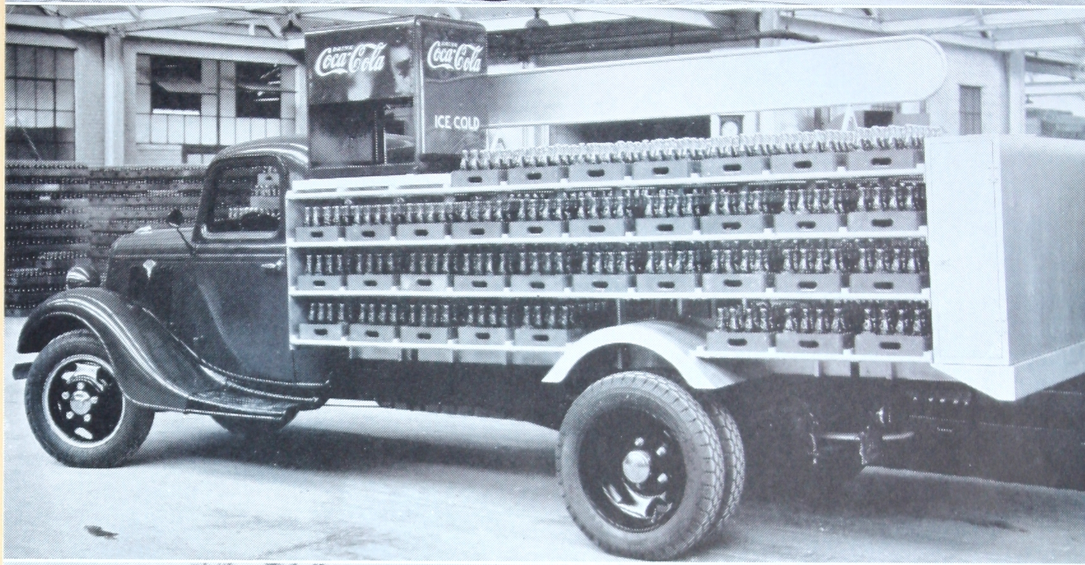
Above: All of the framing on this President's Conference Committee street car is of Republic Double Strength Steel. These cars are built by St. Louis Car Co. for various street railway lines.

Below: Republic Double Strength Steel was used for all heavily stressed parts in the underframes on the streamlined cars of "The Challenger," crack Union Pacific train built by Pullman Standard Car and Manufacturing Co., Chicago.

THESE FIRMS REDUCED DEAD WEIGHT— CUT MAINTENANCE COSTS ON TRUCK FLEETS

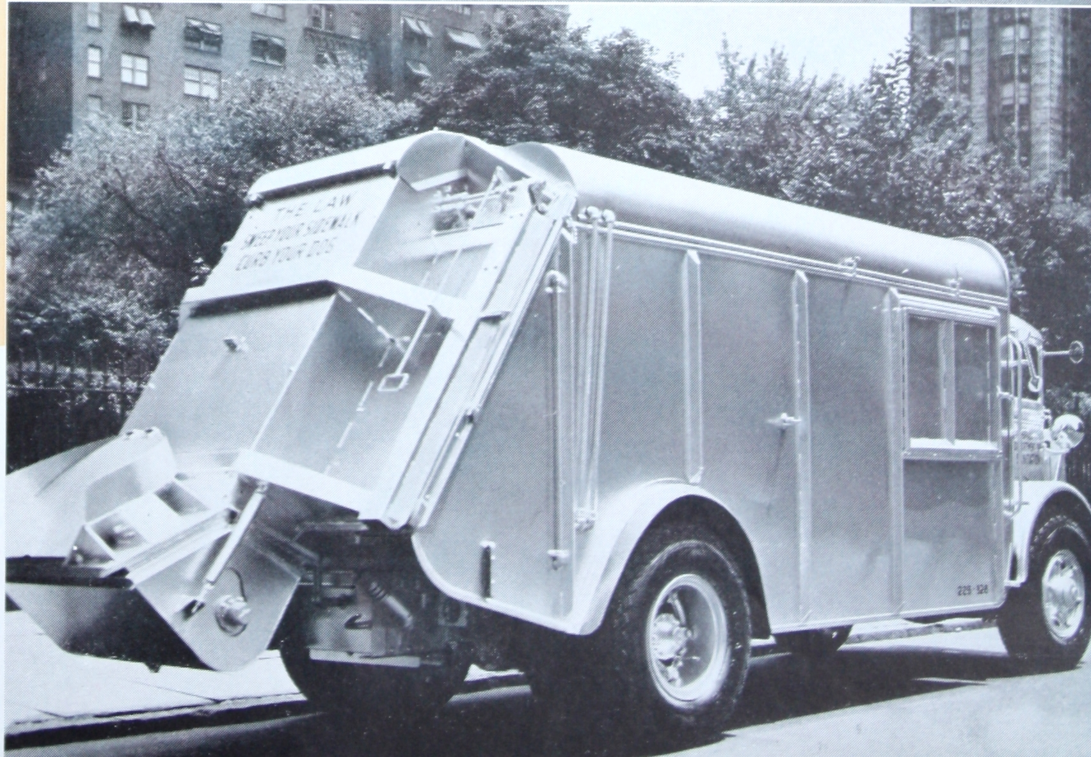
Wright Coal Co., Chicago, reports that this truck (above right) has been in service 5 years without any maintenance expense for the body.

At the right is the original light weight truck built in 1936 by Specialty Engineering Co., Philadelphia, for Coca-Cola. The entire body is of Republic Double Strength Steel sheets and strip, 16 and 18 gauge.



Mid-West Fuel Co. first used Republic Double Strength Steel for their truck bodies 5 years ago and are well pleased with results. Pictured here is a truck after 5 years of hard service.

The Department of Sanitation of New York City maintains a large fleet of garbage trucks. Here is one of the 465 trucks which have quality-built bodies made from Republic Double Strength Steel by The Heil Co., Milwaukee. Its capacity is 21 cubic feet.



Wisconsin Ice and Coal Co., Milwaukee, report that the bodies of their ice and coal dump units made from Republic Double Strength Steel (see photos at left, and below) last two or three times as long as those previously used. Furthermore, the light weight of these bodies increases their hauling capacity. These bodies were made by The Heil Co., Milwaukee.

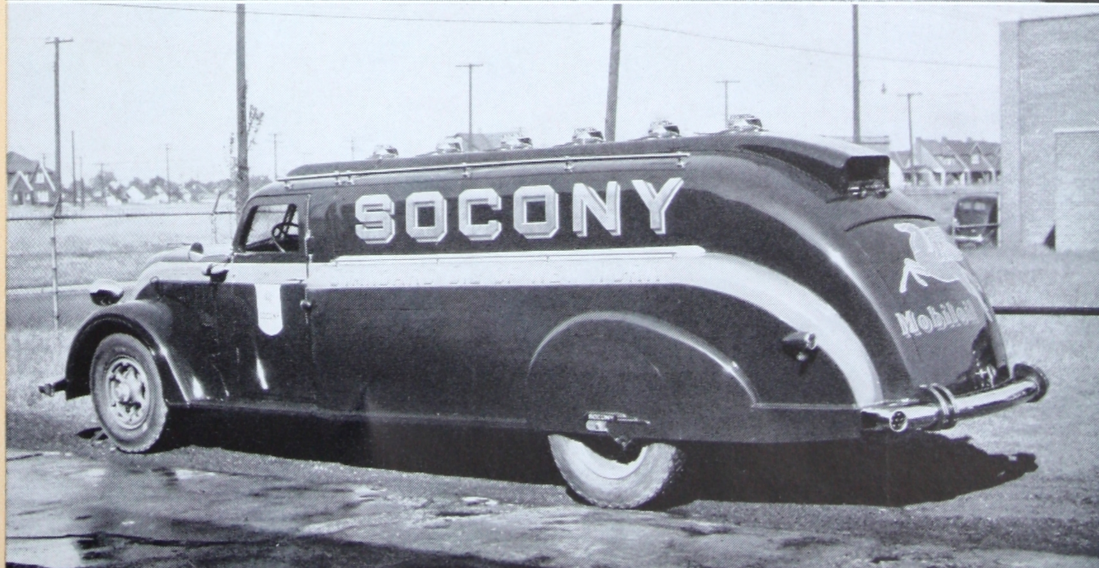
Bottom: Edgefield Coal Co., Canton, Ohio, reports that each of these 3 trucks can handle 10,000 pounds of coal with a tractor weighing less than 5,000 pounds. 12-gauge Republic Double Strength Steel was used by the body manufacturer, The Heil Co.

OIL COMPANIES SUCCEED IN HAULING MORE GALLONS AND REDUCING DEAD WEIGHT

This Cities Service truck (above right) is lighter because Republic Double Strength Steel was used for the tank. It was the first light weight tank truck to be built by Quaker City Iron Works, Philadelphia.

This is one of a large fleet of trucks built in 1936 with the complete tank and supporting members made from Republic Double Strength Steel. It is still in good condition, still carrying 300 extra gallons per trip.

The Holt Oil Co., Federalsburg, Md., reports that this truck hauls 935 gallons more than the truck it replaced because of the use of Republic Double Strength Steel.



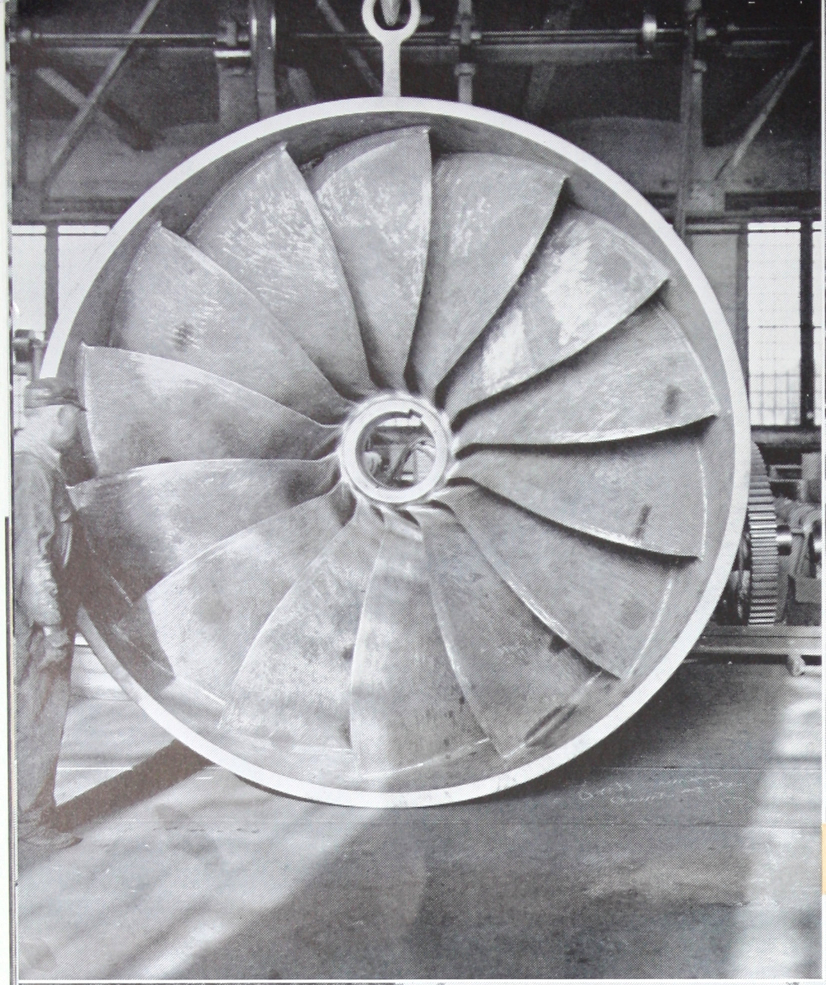
Here is the first stream-lined fuel oil tank. It was made completely from Republic Double Strength Steel by Gar Wood Industries, Inc., Detroit. Note the unusual beauty of its lines.

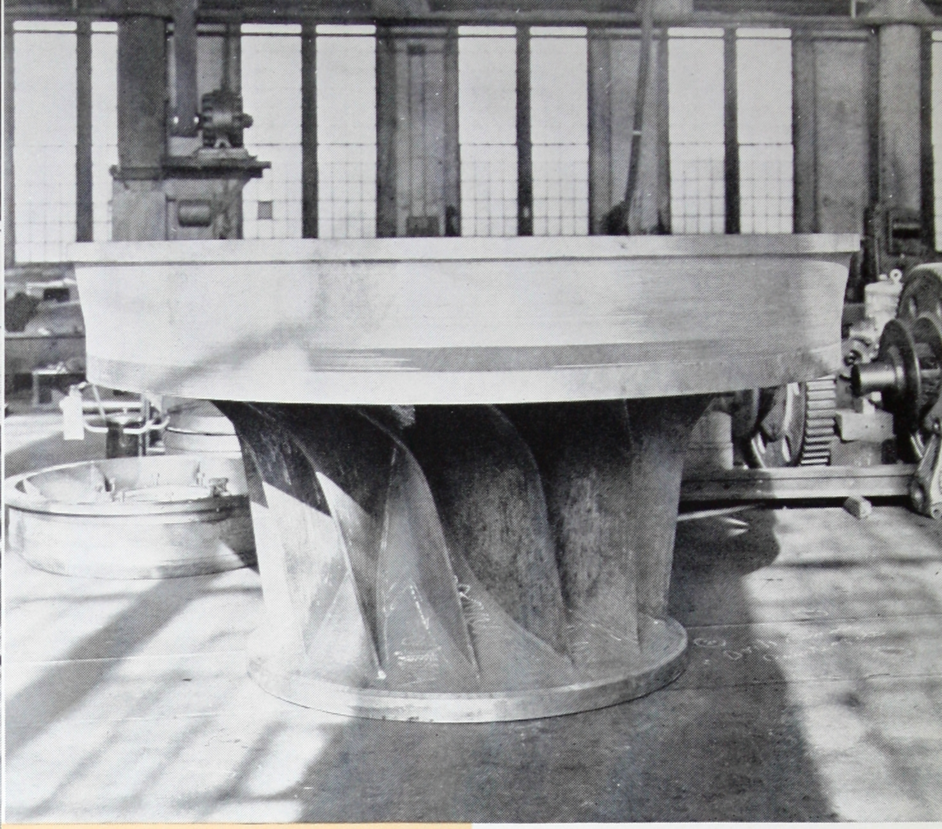
Left: Sunlight Coal Co., user of these two trucks, writes: "In October, 1937, we put into service these two trucks, carrying a pay-load of 30 tons in a specially-designed body constructed of 10-gauge (.141 inches) Republic Double Strength Steel. We are pleased to state that these trucks have carried 381,857 tons of coal and we have not had a single delay due to body failure." Obviously, these bodies, built by Mack Truck Company, Allentown, Pa., must withstand an unusual amount of abrasion and impact.

Below: A La Plant-Choate Bulldozer manufactured by National Steel Car Corp., Ltd., Hamilton, Ont. Mold boards, or blades, are made from Grade No. 1-A because impact at low temperatures was an important service condition. The vital parts of the frame are of Grade No. 1.

BOOM WEIGHT CUT 30%— LIFTING CAPACITIES INCREASED

This 13-ton capacity crane, product of the Thew Shovel Co., Elyria, Ohio, operates with a 75-foot boom and a gooseneck tip extension. The boom is an all-welded structure made entirely from Republic Double Strength Steel. The use of this material permitted the basic boom length to be increased from 60 feet to 80 feet. The extension boom increased length to 110 feet with the result that lifting capacities were increased, boom weight cut 30%. Counter balance weight was, of course, correspondingly reduced.





Above: S. Morgan Smith Co., York, Pa., manufacturers of this turbine-type water wheel, say of Republic Double Strength Steel: "Our Designing and Production Departments find that this steel is exceptionally clean, is easily formed both hot and cold, and machines very well. In addition to this, it has very good welding properties." Stress relieving of these wheels after welding at temperatures of 1100°F. to 1150°F. does not reduce the physical properties of Republic Double Strength Steel.

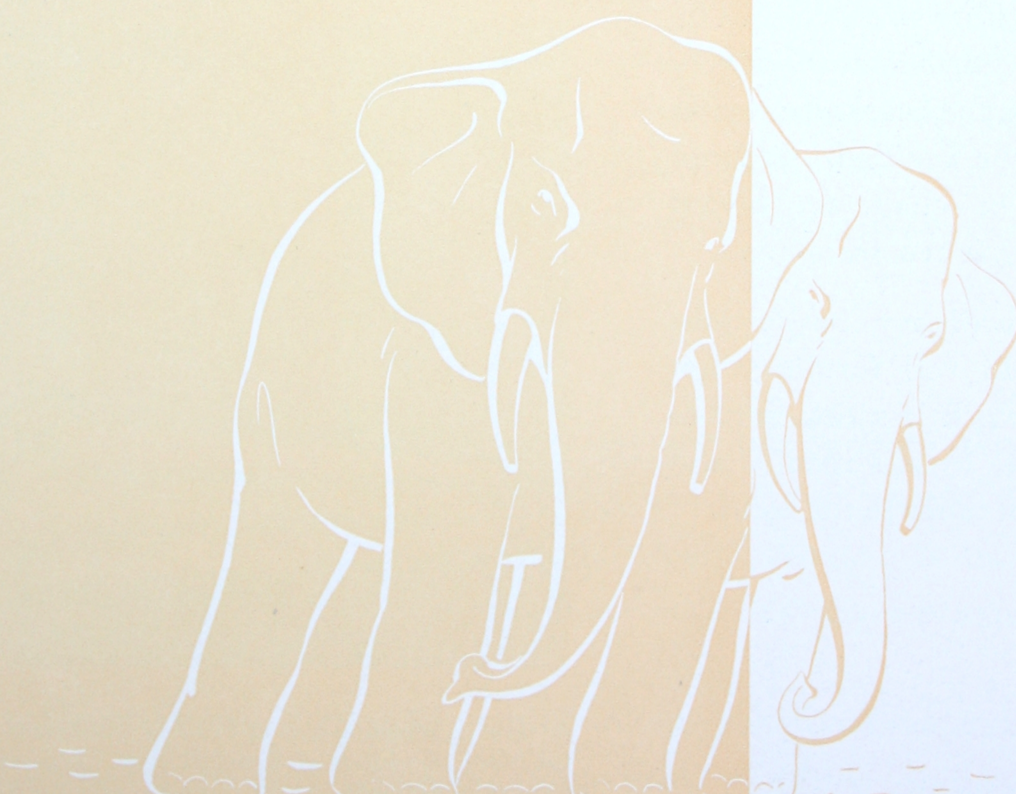
At Left: Welding Republic Double Strength Steel floor plates, $\frac{5}{8}$ inch thick, to the girders at the new underpass at Irondale, Alabama. Plates were sheared 54 feet long and 54 inches wide with a maximum camber of $\frac{1}{8}$ inch for the entire length. The project was completed by Howton Construction Co. Resistance to corrosion was the major reason for using Republic Double Strength Steel.

FABRICATION

OF REPUBLIC

DOUBLE STRENGTH STEEL

The ease with which Republic Double Strength Steel can be welded is by no means its only outstanding fabricating quality. It can be cold and hot formed very readily. It can be machined and riveted, even deep drawn, without unusual precautions. Specialists of Republic Steel Corporation stand ready to advise and work with users who encounter complicated fabrication problems.



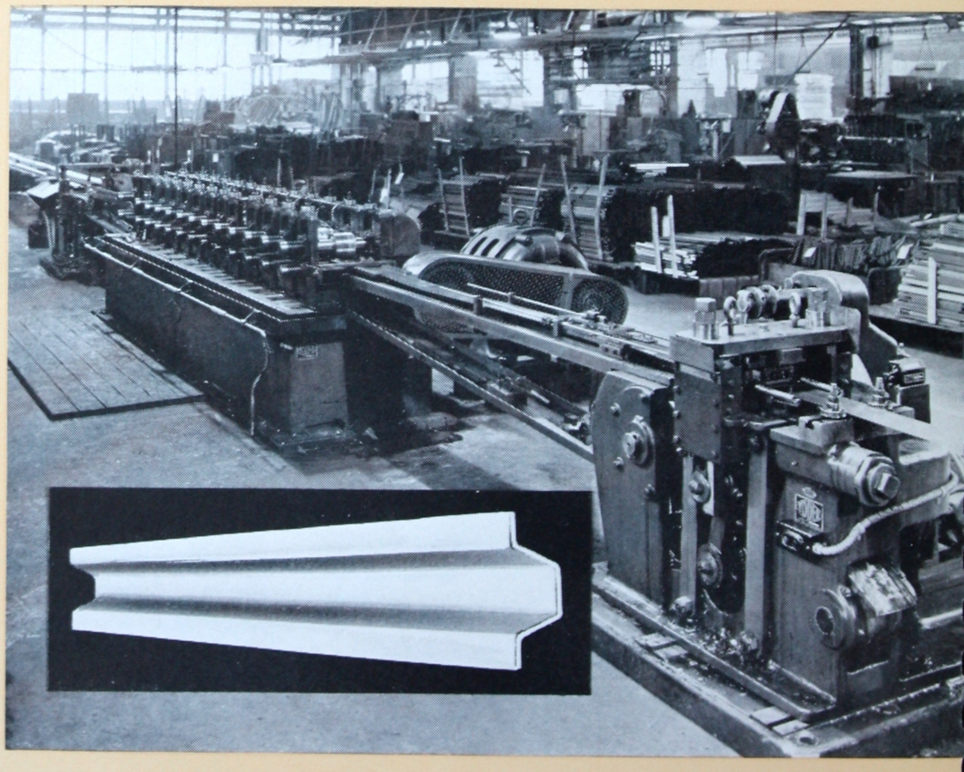
COLD FORMING

Because of its low carbon content, Republic Double Strength Steel cold forms much more satisfactorily than some A.S.T.M. structural steels. When Republic Double Strength is cold formed, the following recommendations should be observed:

	Thickness	Bend	Radius of Bend
Grade No. 1	Up to .066″	180° flat	
	.066″ to .125″	180°	1 times thickness
	$\frac{1}{8}$″ to $\frac{3}{16}$″	90°	$1\frac{1}{2}$ times thickness
	$\frac{3}{16}$″ to $\frac{3}{8}$″	90°	2 times thickness
	$\frac{3}{8}$″ to maximum size produced	90°	$2\frac{1}{2}$ times thickness
Grade No. 1-A	Up to $\frac{3}{16}$″	90°	2 times thickness
	$\frac{3}{16}$″ to $\frac{3}{8}$″	90°	3 times thickness

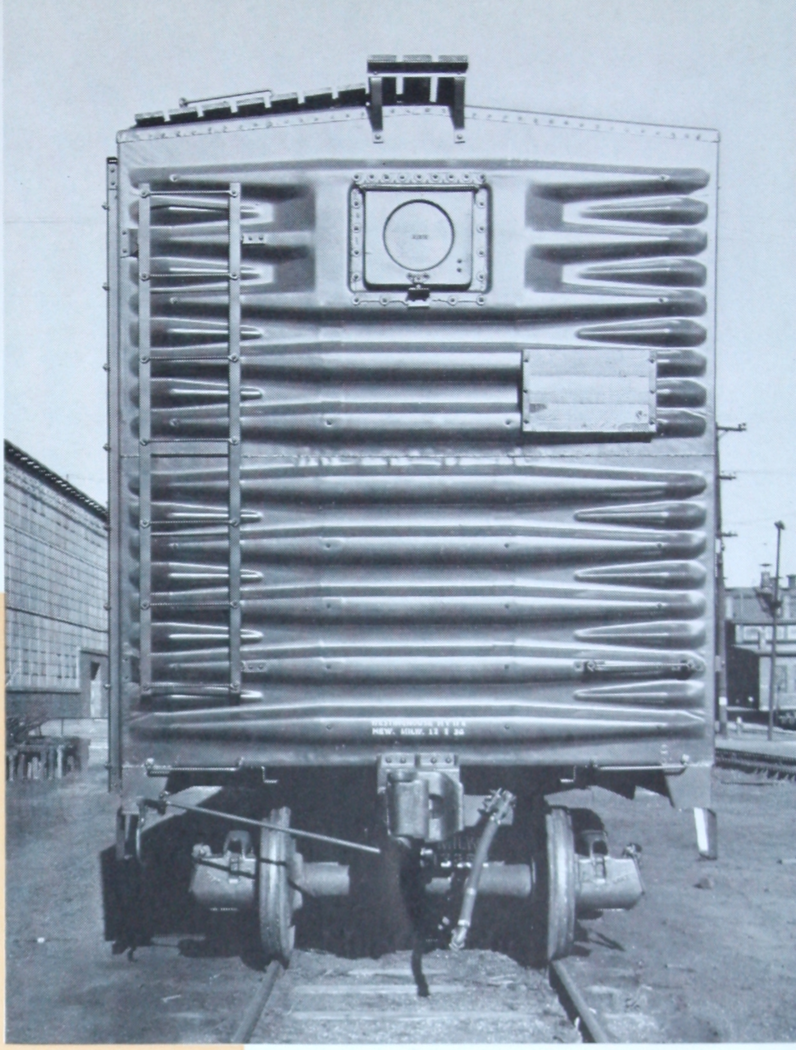
Steel should not be cold formed when its temperature is below 60° F. If steel has been stored outdoors when the temperature is low, it should be brought into a heated building and allowed to remain until it reaches room temperature. When laying out sections, do not use scratch lines made by sharp instruments as this practice causes concentration of stresses, reducing the fatigue limits. When such a condition exists, 24,000 pounds fiber stress cannot be used. Furthermore, heavy prick punch marks for layout should be avoided. Colored pencil or chalk for layout marking is recommended.

For ordinary brake jobs and cold roll forming, hot rolled stock is satisfactory as the scale breaks readily and does not damage the tools.



A view of continuous cold forming equipment at Truscon Steel Company, subsidiary of Republic Steel Corporation. Here many sections of Republic Double Strength Steel are cold formed. *Inset:* A typical section.

HOT FORMING



A hot pressed Murphy box-car end. The lower half is Republic Double Strength Steel, $\frac{5}{32}$ inches in thickness. Fabricated by Standard Railway Equipment Co., Chicago, Ill.

The hot rolled finish, not pickled, is used where hot forming, dishing and spinning operations are to be performed by the fabricator. In such cases the material should not be ordered with specified physical requirements, as hot working sometimes alters the physicals produced at the mill. If the material is properly hot worked by the fabricator, it will meet the physical properties listed.

For hot forming it is recommended that the material be heated to 1600° F. in a smoky flame. It should not be soaked long at this temperature, however. By the time the material has been placed on the die, it will probably drop to 1450° F. which is the proper forming temperature. At this temperature it will readily form over a radius equal to the thickness of the material. Normalizing after hot forming usually is not necessary and is not recommended. However, if such treatment is necessary, due to unusual circumstances, 1600° to 1650° F. is the correct normalizing temperature to observe. The material should be heated throughout but not soaked, and then cooled freely in air.

DEEP DRAWING

Although Republic Double Strength Steel does not possess the ductility of ordinary low-carbon steels for deep drawing, it is more satisfactory for this purpose than the ordinary structural steels. The ductility of Republic Double Strength is about 70% of that of ordinary hot rolled sheet or strip and, of course, more power is required to form it.

Where drawing is performed, pickled or pickled and oiled material should be used. The lubrication practice in drawing is the same as that used for ordinary sheets or strip.

RIVETING

The same riveting procedure is used for Republic Double Strength Steel as for structural steels. In driving hot rivets made from Republic Double Strength Steel, rivets should be heated to a temperature not to exceed 1700° F. Care should be taken to reduce scale by not leaving rivets in the heating furnace too long. When driving cold rivets, Republic Double Strength Steel is handled exactly like ordinary steel. Use of rivets made from Republic Double Strength Steel is very desirable where high shear stresses are required or where resistance to corrosion is necessary.

MACHINING

Republic Double Strength Steel can be satisfactorily machined. Of course, due to its high alloy content, toughness and ductility, it requires slower cutting speeds than ordinary steels of the same hardness. Because of its high ductility, greater difficulty will be encountered in drilling and reaming operations. Its high yield point demands that more pressure in punching be applied.

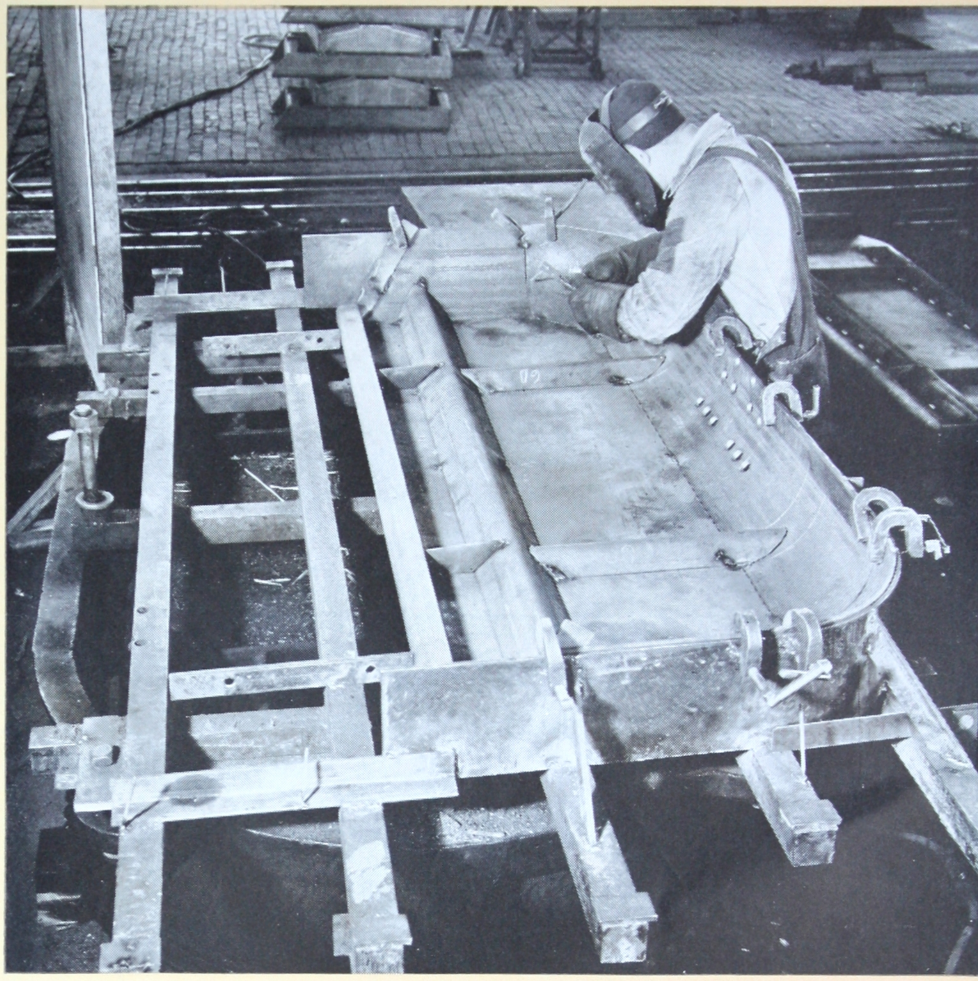
WELDING

In the development of Republic Double Strength Steel, welding qualities were considered of maximum importance. That is why steel with practically no air hardening characteristics was developed. Republic Double Strength Steel can be arc welded and resistance welded without any precautions other than those required in welding ordinary steel.

GAS WELDING

Gas welding on light gauges, 18 or under, can be done successfully without loss of physical properties. This practice is not desirable on heavier gauges, 16 and up, due to higher cost.

ARC WELDING



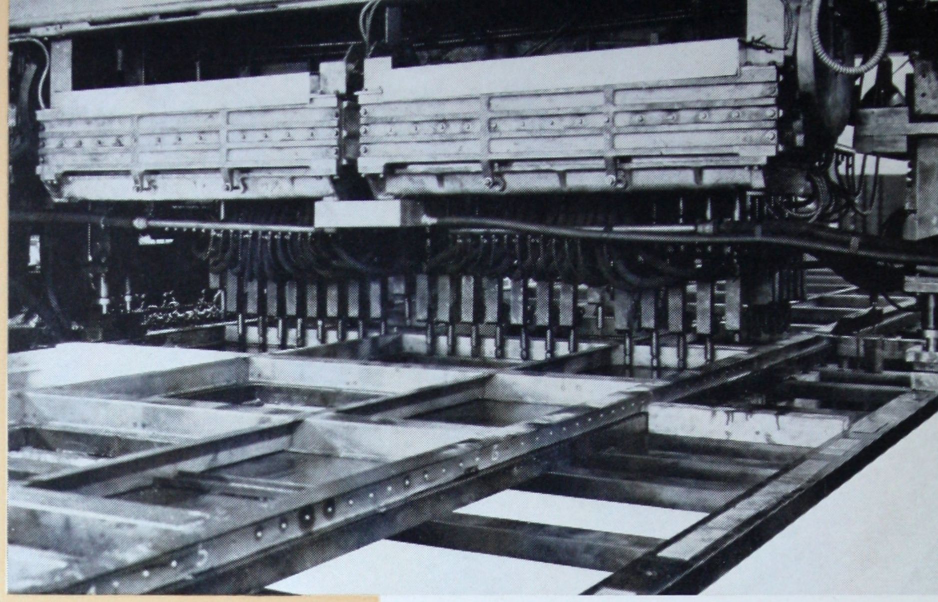
Arc welding the body of a Granby type ore car at C. S. Card Iron Works Co., Denver, Colo.

Any welds which can be made on carbon steel can be made on Republic Double Strength. It should be arc welded with coated electrodes. If electrodes require reversed polarity, the manufacturer can advise in this respect. Arc welds made on Grade No. 1 show little increase in hardness in the weld or adjacent zone. Hardness tests have shown that there is usually an increase of 2½% to 12% in the welded zone, whereas in a plain carbon steel of equal strength (approximately .35% carbon), the increase will run as high as 75%. From a metallurgical standpoint, welded structures of Grade No. 1 do not require stress relieving after welding. However, the design of the structure may be such that shrinkage stresses in the welded zone are high. These can only be relieved by cold peening or, preferably, reheating to a temperature of 1150° to 1200° F. Stress relieving at this temperature will not reduce the physicals.

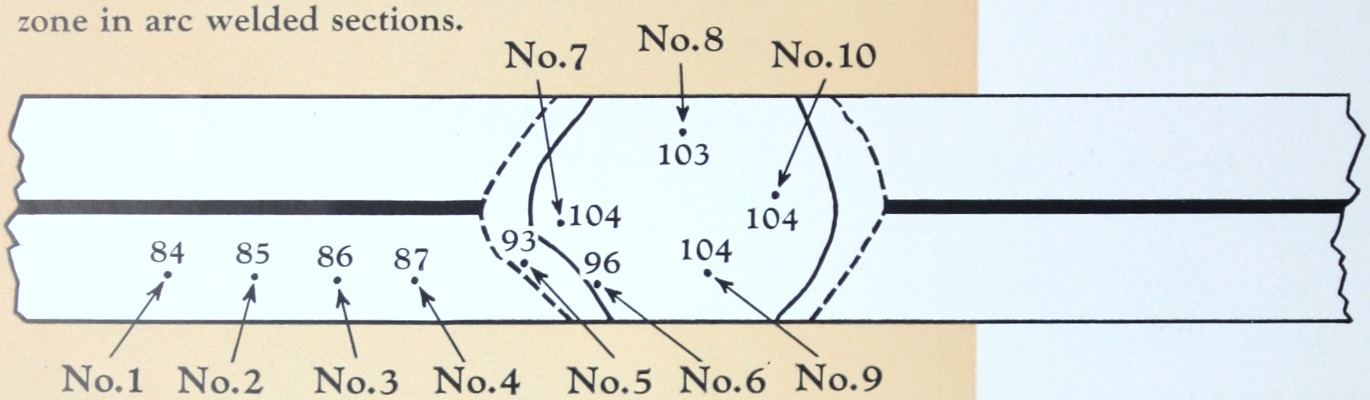
Grade No. 1-A, due to its higher carbon content, does air harden when welded. Consequently, any heavy structure of this type should be stress relieved by heating the entire part to 1150° or 1200°F. In some cases, light gauge material, 11 and lighter, may be relieved by reheating with the torch. Prints of structures to be welded from Grade No. 1-A should be submitted to the mill for recommendations regarding stress relieving.

SPOT WELDING

Republic Double Strength Steel may be spot welded satisfactorily. For this purpose pickled material should be used, as the resistance set up by scale decreases the speed of welding and increases the danger of poor welds. Lower heat and more time than used for carbon steel produces the best results. The spots harden slightly more than the weld zone in arc welded sections.



Spot welding the side sections of a light weight, stream-lined coach being built for Delaware and Hudson by American Car and Foundry Co.



Cross-section of a spot weld showing Rockwell B hardness reading

Note that the increase in hardness is only 25% over or above the original hardness of the sheet. This weld was made with cooling water in contact with the metal. Spot welding of Grade No. 1-A is not recommended, due to the high hardness produced in the welds, making them brittle.

Position	Rock. B	Position	Rock. B
1	84	6	96
2	85	7	104
3	86	8	103
4	87	9	104
5	93	10	104

ELECTRODES

All of the regular sources of supply offer welding electrodes suitable for Republic Double Strength Steel Grades No. 1 and No. 1-A.

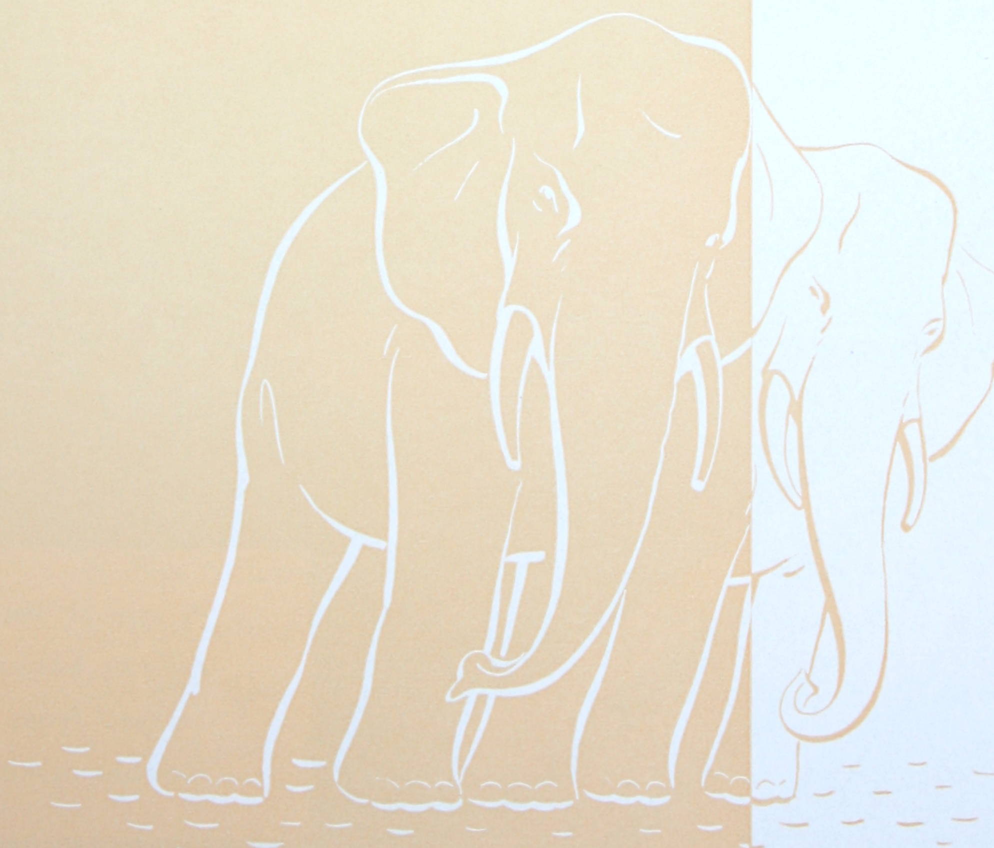
GAS CUTTING

Gas cutting is successful on Grades No. 1 and No. 1-A. Usually it is necessary merely to grind off about $\frac{1}{16}$ inch to remove the affected zone. Grade No. 1-A has a tendency to harden along cut face. It is usually necessary to remove more stock from this type by grinding cut face. Parts made by gas cutting from flat stock rolled to physicals are satisfactory after grinding the gas cut face to remove irregularities and hardened area.

AVAILABILITY AND FORMS

OF REPUBLIC DOUBLE STRENGTH STEEL

For any information about sizes, gauges, finishes and special forms not presented on pages 38 and 39, you are invited to write to Republic Steel Corporation, Alloy Steel Division, Massillon, Ohio. Or get in touch with our nearest District Sales Office. (See back cover.)



A typical assortment of railway box-car sections formed from Republic Double Strength Steel.

SIZES • GAUGES • FORMS

Hot Rolled Sheets are available in the following gauges and widths:

Gauge (Inches)	Maximum Width (Inches)	Gauge (Inches)	Maximum Width (Inches)
.060	48	.134	76
.075	52	.150	82
.090	60	.164	84
.105	66	.187	86
.120	72	.200 to .500	88

Hot Rolled—Normalized—Leveled

3/8″ maximum thickness - 48″ wide (maximum) up to 40′ long

3/8″ maximum thickness - - 50-60″ wide up to 14′ long

Hot Rolled Angles (Same as carbon Steel)

From 1/8″ to 7/16″ thick - Leg dimensions 3/4″ x 3/4″ to 4″ x 6″

Formed Sections are obtainable upon application.

FINISHES

1. Hot rolled
2. Hot rolled—pickled
3. Hot rolled—pickled—oiled
4. Hot rolled—normalized—leveled
5. Hot rolled—normalized—leveled—pickled
6. Hot rolled—normalized—leveled—pickled—oiled
7. Cold rolled. (Available upon application.)

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CONDENSED LIST OF PRODUCTS

REPUBLIC STEEL CORPORATION AND SUBSIDIARIES

BAR MILL PRODUCTS

Alloy Steels, Carbon Steels, Toncan Iron, Enduro Stainless Steels, Republic Double Strength Steel, Nitralloy—Rounds, Squares, Hexagons, Octagons, Half Rounds, Flats, Bands, Angles, Concrete Reinforcing Bars, Maney Guard Rails, Spring Steel Flats, Tie Plates, Special Sections.

BESSEMER STEELS

BOLTS, NUTS AND ALLIED PRODUCTS

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Galvanized Corrugated Metal Pipe (Full Riveted, Part Circle and Nestable) Brands—Toncan Iron, No-Co-Ro Copper-Bearing Iron, Central Pure Iron, U-Loy Copper-Bearing Steel—Plain and Perforated. Toncan Sectional Plate Pipe and Arches, Tyton Sluice Gates, Toncan Triple Clad Drainage Pipe, CorWel Subdrainage Pipe.

ELECTRIC FURNACE STEELS

Republic Alloy Steels, Enduro Stainless and Heat-Resisting Steels, Carbon Steels.

ENDURO STAINLESS AND HEAT-RESISTING STEELS

All Standard Chromium and Chromium-nickel Types—available in Sheets, Hot and Cold Rolled Strip, Plates, Hot and Cold Drawn Bars, Tube Rounds, Slabs, Billets, Bolts, Nuts, Rivets—All Commercial Finishes.

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Desks, Tables, Cabinets of all kinds, Files, Shelving, Special Office Furniture, Lockers, Trays, Bins, Racks of all kinds, Special Units, Counters, Air Conditioning Cabinets, Parts Boxes, Display Equipment, Sink Cabinets, Wall Cabinets, Furnace Jackets, Voting Machines, Silentaire Window Ventilators, Complete Line of Sheet Metal Building Products, Metal Lath, Plastering Commodities and Steel Ceilings.

HEAT-TREATED OR ANNEALED PRODUCTS

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PIG IRON

"Chateaugay"—Low Phosphorus.
"McKinney"—Basic, Foundry and Malleable.
"Niagara"—Basic, Foundry and Malleable.
"Pioneer"—Basic and Foundry.
"Republic"—Bessemer.

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Track, Boat and Barge Spikes.

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Hot and Cold Rolled Steel, Republic Double Strength Steel, Toncan Iron, Coiled Silicon Steel, Enduro Stainless Steel.

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